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WILLIAM CODMAN STURGIS

ROBERT HAGELSTEIN

(WITH PORTRAIT)

William Codman Sturgis was born at Boston, Massachusetts, on November 15, 1862. He studied at Harvard, receiving degrees in 1884, 1887 and 1889. His first scientific work was as assistant in the Cryptogamic Laboratory of Harvard, followed as vegetable pathologist at the Connecticut Agricultural Experiment Station, lecturing meanwhile at the Yale School of Forestry. In 1904 he joined the staff of Colorado College, and later for nearly ten years was dean of the School of Forestry there. In 1917 he came to New York, and the remaining years of his life were connected with various activities of the Protestant Episcopal Church. He passed away on September 29, 1942.

Dr. Sturgis is perhaps best known for his studies on the Myxomycetes, although his work in plant pathology, forestry and mycology is not to be ignored. He became interested in the group while in Connecticut, and visiting England in one of the early years of the century, he was a guest for some time at the home of Mr. and Mrs. Arthur Lister. That visit resulted in lengthy correspondence with Mr. Lister until the latter's death, and continued with his talented daughter, Miss G. Lister, for many years afterward. From each he received many rare specimens, particularly of type material of new species proposed by them.

During his long residence in Colorado, Dr. Sturgis made extensive collections of the Myxomycetes of the State, among which

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were several forms which he proposed as new species. The results of the study of these specimens, as well as other researches in the group, were published in different scientific journals. The entire collections of Dr. Sturgis, together with his notes, books, and correspondence, are now in the Herbarium of the New York Botanical Garden.

My personal acquaintance came about in New York in 1924 when I heard he had his office but a few blocks removed from mine. That acquaintance ripened into a friendship, and I recall with tender memories the many happy hours spent together in discussing problems connected with our mutual hobby. I met him last on a visit to his beautiful home at Annisquam, Massachusetts, during the month of May, 1938.

With the passing of each dear friend, and as we grow older, there is a void in our hearts which cannot be filled. As I sit at dusk, fond recollections come back to me of the long, long ago.

THE NEW YORK BOTANICAL GARDEN,
BRONX, NEW YORK CITY

FUNGI OF SOUTHERN CALIFORNIA—II [1]

ALEXANDER H. SMITH AND PAUL M. REA

As already pointed out by Rea,[2] the fungous flora of southern California has a number of interesting aspects. Several years of field work have already yielded valuable information on the distribution of fungi in the southwestern corner of the United States and, as is to be expected in a survey of any relatively unexplored region, a number of very odd and interesting agarics have been collected. Some of these are the subject of this report. Others are withheld for the present because they belong to groups in which the distinguishing characters are not sharp and more information is needed to justify extensive revisions. Since a comprehensive fungous flora of this region is a remote possibility, serial publication of the studies as they progress is desirable to make the results available to other workers, particularly those engaged in critical revisions of generic concepts.

This paper treats eight species, four of them new, distributed in *Amanitopsis*, *Armillaria*, *Cortinarius*, *Lepiota* and *Melanoleuca*. The genus *Melanoleuca* is used in the sense of Patoulliard, not Murrill. The most interesting of the new species is perhaps *Armillaria subcaligata*, which is characterized by ellipsoid, amyloid spores, bilateral gill trama, adnexed-seceding lamellae and the general appearance of *A. caligata*. Because of its gill trama, its relationships must be in the *A. imperialis* group of species, but the latter is characterized by differently shaped spores and long-decurrent lamellae. *Melanoleuca Lewisii* is a fine example of how deceiving external appearances can be. Most species of *Melanoleuca* are so similar in stature that the genus can usually be identified at sight, though the species can be distinguished only after careful study. The genus is similar to *Russula* in this respect. In *M. Lewisii*, however, we have a species which does

[1] Papers from the University of Michigan Herbarium and from the Herbarium of Paul and Marian Rea, Santa Barbara, California.

[2] Rea, Fungi of Southern California I. Mycologia **34**: 563–574. 1942.

not resemble a *Melanoleuca* in appearance but must necessarily be placed there by virtue of the microscopic characters upon which the genus is based.

AMANITOPSIS VELOSA Peck.

Pileus 4–9.5 cm. broad, convex to nearly plane, viscid when wet but soon dry, pale buff to orange-buff, margin sulcate-striate (very rarely even), almost invariably with one large patch of the thick felt-like white volva covering the disc, usually glabrous elsewhere; flesh white, unchanging, thick next to the stipe, 4–10 mm., thinning rapidly to the margin, odor strong and pungent; lamellae close, usually pale creamy but often white, sometimes assuming a pronounced pink color when past maturity, broadest near the cap margin (5–8 mm.), subventricose, narrowed toward the stipe and decurrent on it by lines, edges fimbriate; stipe 8–15 cm. long, stout, 6–9.5 mm. or more thick at the apex, equal or slightly tapering upward, not bulbous, the base within the volva tapering to a point, pruinose above and roughened by decurrent lines where the lamellae were attached and then torn loose, without an annulus but sometimes with an obscure zone where the margin of the pileus was in contact with the stipe, glabrous below but with the cortex sometimes ruptured in irregular partial rings by the elongation of the stipe, white within, solid, with a central pithy core, becoming hollow; volva white, ample, membranous, closely sheathing the base for about 2 cm., dividing above into two limbs, the outer free, about 1 cm. long, with a more or less regular margin, the inner thicker, short, usually 3–4 mm., pressed against the stipe, in some specimens showing clearly that it is part of the cortex of the stipe ruptured by elongation of the latter.

Spores globose to ovate, 8.4–11(12.6) × 6–10.8 μ, hyaline, apiculate, not amyloid, smooth; basidia 4-spored, occasionally 2-spored, 60–80 × 12–14 μ; pleurocystidia not differentiated; cheilocystidia more or less like sterile basidia (hardly differentiated); gill trama of somewhat divergent hyphae, not amyloid; pileus trama floccose beneath a thick gelatinous pellicle, not amyloid.

Solitary to gregarious, usually under or near oak trees, common, February to April in the region around Santa Barbara. The type locality is Pasadena, Calif. Wm. B. Gruber collected it in the vicinity of Roseburg, Ore., Apr. 14, 1942.

Observations: In early development, before expansion, the

fundamental tissue surrounds the stipe and extends in a very thin sheet between it and the lamellae, with which it is intimately united. It is the thinness of this sheet that prevents formation of an annulus. Expansion of the pileus tears the lamellae free and leaves their edges fimbriate. Most of the fundamental tissue then collapses on the stipe. The exposed surface of this tissue is striate above from the lamellae. Toward the base of the stipe it is thicker and soon becomes ruptured transversely as the stipe elongates leaving the lower part as the inner limb of the volva. Sometimes when the line of rupture is uneven its irregularities correspond on the rim of the inner volva and on the bottom of the cortex above. This development is similar to that of *A. vaginata* as described by Atkinson, and these species appear to be closely related. However, *A. velosa* is distinguished by its pungent odor, the heavy calyptra, color of the pileus, lamellae reaching the stipe, regular presence of the inner volva and the variation of the spores from globose to ovate. *A. vaginata* sometimes has a few volval remains on the pileus but seldom if ever a large, thick calyptra. It sometimes has an inner volva. *A. vaginata fulva*, as we know it, is more tawny. Its spores are described as globose and we have always found them so, whereas in *A. velosa* the spores, although often globose, are commonly as much as 3 μ longer than broad. In a series of 82 spores from 11 collections the average size is $10.5 \times 8\ \mu$.

A. velosa also appears to be closely related to *Amanita calyptroderma*. Both are bivolvate and calyptrate, have a striate margin, lamellae reaching the stipe at least at first, and non-amyloid spores. Although the latter species has a pileus about twice as large as the former and is much more robust in all its parts, its chief distinction is the presence of an annulus which is ample, though thin, and which readily collapses on the stipe. The formation of the annulus is due merely to slightly greater strength of the upper part of the fundamental tissue. Since the annulus is strictly apical, the striations from the lamellae are on its upper surface rather than on the stipe. Because of their pink gills, old carpophores of *A. velosa* may at times be mistaken for a species of *Volvaria* if one does not take the trouble to obtain a spore print.

Armillaria subcaligata sp. nov.

Pileus 5–11 cm. latus, convexus, demum late convexus vel planus, squamosus; squamae vinaceo-brunneae, 5± mm. latae, recurvae vel ad marginem pilei applanatae; lamellae latae, subventricosae, secedentes, subdistantes, albidae vel pallide luteotinctae; stipes 6–10.5 cm. longus, 2 cm. crassus, deorsum attenuatus, sursum glaber et albidus, deorsum peronatus, solidus; annulus 1± mm. crassus, infero luteo-brunneus, superne albidus; sporae 9.6–12 × 7.7–9.6 μ, amyloideae.

Pileus 5–11 cm. broad, broadly convex, expanding to nearly plane but not becoming umbonate, surface dry and covered with large subpyramidal innate scales 5± mm. in width, scales pinkish brown with darker tips, toward the margin the scales more fibrillose and appressed, the flesh between the scales (ground color) whitish, the margin incurved and exceeding the lamellae by 3–4 mm. and the inner side striate from contact with the lamellae; flesh pure white, unchanging, compact but soft, 13 mm. thick next to the stipe, thinning gradually to 2 mm. at the margin, odor none; lamellae very broad (15–18 mm.), subventricose, rounded behind and definitely adnexed but seceding, leaving decurrent lines on the stipe, thin, white with a faintly yellowish and waxy tinge, subdistant, unequal, not forking, edges eroded; stipe 6–10.5 cm. long, about 2 cm. thick at the apex, narrowed downward, about 14 mm. at base, white and glabrous above the annulus, below the annulus sheathed by the thin yellowish-brown universal veil that forms subconcentric brown scales, solid, white within; annulus superior, the veil in the unbroken state 1± mm. thick and continuous with the flesh of the pileus, its upper or inner surface white and smooth, its lower or outer surface cottony-floccose and bearing thick brownish-capped scales like those of the pileus, soon collapsing on the stipe and becoming inconspicuous.

Spores 9.6–12 × 7.8–9.6 μ, ellipsoid, amyloid, smooth; basidia 50–60 × 10–12 μ, 4-spored; pleuro- and cheilocystidia not differentiated; gill trama with a central strand of more or less parallel hyphae with other hyphae diverging from it, not amyloid; pileus trama homogeneous, not amyloid, surface fibrils grouped into fascicles which form the scales.

Collected by Miss Heloise Coutelenc, Aug. 7, 1941, on a dry lawn near shrubbery in Santa Barbara, Calif.; in Herb. Paul and Marian Rea (*994*) and Univ. Mich. Herb.

Observations: The relationships of this species are puzzling. Although it is almost identical with *A. caligata* in stature, color

and veil characters, it differs sharply in having large, ellipsoid, amyloid spores and divergent gill trama. The ellipsoid spores, adnexed gills and veil characters make it difficult to place the species in either *Catathelasma* or *Biannularia*. Consequently we have described it in the Friesian genus *Armillaria* in order to place it on record. Most collectors along our west coast will doubtless confuse it with either *A. caligata* or *A. ponderosa* if the microscopic details are not checked.

Cortinarius regalis sp. nov.

Pileus 8–12 cm. latus, subplanus, siccus, albofibrillosus vel subcalyptratus, glabrescens, subavellaneus vel avellaneo-subincarnatus; lamellae subdistantes, latae, pallidae dein umbrino-avellaneae; stipes 7–16 cm. longus, 18–35 mm. crassus, marginato-bulbosus, albidus vel pallidus, fibrillosus dein subsquamulosus; sporae 7.2–8.4 × 4.8–5.4 μ.

Pileus 8–12 cm. broad, hemispheric with an inrolled margin at first, soon nearly plane, obtuse or broadly umbonate, the margin sometimes becoming wavy and at length somewhat raised, at first clothed with a thick, pure white fibrillose universal veil whose remnants often persist as a calyptra or in patches, cuticle beneath this covering "avellaneous" [3] with a faint tint of heliotrope, finally "vinaceous drab" (with a faint flesh tinge) and somewhat streaked with appressed fibrils, cuticle smooth and somewhat moist at first but no gelatinous pellicle present; flesh thick under the disc, thinner toward the margin, scissile and more or less watery punctate when fresh, drab in spots but gradually becoming a uniform vinaceous drab (paler than pileus); lamellae subdistant, inserted, broadest near the stipe, 8–11 mm., becoming ventricose as the pileus expands, very deeply emarginate-adnexed, pallid in the button stages (scarcely violaceous), becoming grayish brown to more or less chocolate brown when moist, paler and more rusty in dried specimens, not becoming purplish when bruised, edges even; stipe 7–10.5 (16) cm. long including the bulb, very thick, 18–35 mm. at apex, solid, its flesh watery punctate like that of the pileus and concolorous with it, tapering upward from the large strongly marginate-depressed or oblique turbinate bulb which is 4–6 cm. thick and 3.5–5 cm. deep to the tapered point, surface of stipe white to pallid, innately fibrillose, becoming coarsely lacerated in age, persistently decorated with abundant fibrils of the universal veil which are soon stained rusty from the spores, partial veil white and evanescent.

[3] All color names within quotation marks are taken from Ridgway, "Color Standards and Nomenclature," 1912.

Spores 7.2–9.6 (10.8) × 4.8–6 μ, subellipsoid, nearly smooth, ferruginous in mass; basidia four-spored; pleuro- and cheilocystidia not differentiated; gill trama hyaline or nearly so in KOH, regular to somewhat interwoven, the hyphal cells not particularly inflated; pileus trama homogeneous beneath a thin nongelatinous pellicle of narrow (1–2 μ) hyaline hyphae with abundant clamp connections.

Densely gregarious to subcespitose in leaf mold under oaks, Santa Barbara, Calif., Jan. 28, 1940 (Rea *333*, type), same locality again Feb. 7, 1940 (Rea *357*). Part of both collections are in the Univ. Mich. Herbarium. It has also been collected under oaks in the Santa Ynez valley, Santa Barbara Co., Jan. 30, 1940 (Rea *334*), and Jan. 20, 1944 (Rea *1309*).

Observations: In spite of its watery flesh this fungus appears to belong in *Inoloma* rather than *Telamonia*, and is most closely related to the large form of *C. obliquus* Peck. Its manner of development is similar to that of *C. obliquus*, but it differs markedly in color. There are no true violet colors in *C. regalis* although a slight illusion of violet may be present at times in the cap or gills. The manner of development is similar to that found in *Bulbopodium*. The bulb may be depressed or merely oblique depending somewhat on the particular conditions at the time fruiting occurs. At times the flesh shows a tendency to turn yellow when cut but the change is not pronounced and the yellowish tints soon fade. *C. regalis* appears closely related to *C. argutus* but has distinctly smaller spores. Ricken gives the spores of the latter as 13–15 × 8–9 μ. The colors and copious veil of the California species are further distinguishing characters.

LEPIOTA FLAVESCENS Morg.

Pileus (1.7) 2.5–4 cm. broad, at first cylindric-ovate and obtuse, at length expanded plane or with an obtuse or flattened umbo, plicate striate almost to the disc, pale greenish yellow (near "naphthalene yellow") over all except the disc, disc glabrous and brown at all stages and contrasting strongly with the rest of the surface, floccose to somewhat powdery over the ridges of the striae, the grooves merely fibrous and whiter; flesh yellowish, membranous; lamellae yellowish, close to subdistant, rather narrow, 2 mm., subventricose, free and remote, edges minutely fimbriate; stipe 3–6.5 (8) cm. long, 3–5 mm. thick at the base,

tapering gradually upward to 2 mm. or less at the apex when fully elongated, pale sulphur yellow and covered with fine yellow flocci like the pileus, hollow; annulus superior, pale yellow, delicate, often disappearing and occasionally becoming movable when the specimens have dried. Gregarious to cespitose, growing from an abundant white mycelium.

Spores 4.8–6.6 (7.2) × 3.5–5 (5.5) μ, broadly ellipsoid to subglobose, not truncate, smooth, pale yellowish brown in iodine; basidia 4-spored, 15–18 × 7–8 μ, clavate; paraphyses voluminous, 14–18 × 10–15 μ, saccate and thin walled; pleurocystidia not seen; cheilocystidia abundant, 28–43 × 8–14 μ, clavate, subcylindric or fusoid ventricose with obtuse apices, thin walled, hyaline; gill trama very loosely interwoven; pileus trama also loosely interwoven, corticated over the brownish disc with a compact palisade of enlarged (clavate to pear-shaped) thin walled cells, with scattered fascicles of inflated cells over the striate portion.

On humus in a greenhouse of Miss Kate Walker, Santa Barbara, California, July 26, 1941 (Rea *983*), and from the same locality again in 1942: Aug. 14 (*1115*), Aug. 20 (*1116*) and Aug. 26 (*1119*). Specimens are also in the Univ. Mich. Herb. The description is based on collection *1115*.

Observations: This species is very closely related to *L. lutea* but can readily be distinguished macroscopically by its dark brown glabrous disc and microscopically by its smaller spores which lack a truncate apex. It also appears to be very close to *L. denudata* Rab. sensu Kühner, but differs in not possessing sphaerocysts in the cuticle of the pileus. The disc is composed of a compact palisade of clavate to pear-shaped cells, and more or less the same type of cell covers the remainder of the surface at first but, owing to expansion, the layer becomes broken up and the cells are found in fascicles along the ridges of the striae at maturity. Judging by the descriptions, there is very little likelihood that *L. Allenae* Peck is different from the species described by Morgan. *L. flavescens* is also very close to *L. spectabilis* Clem. and may prove to be a variety of it. A fungus very similar to *L. spectabilis* was found growing with *L. flavescens* at Santa Barbara (Rea *1120*). It has a paler pileus and yellow rather than brown disc. The spores and all other characters are as in *L. flavescens*.

LEPIOTA GLATFELTERI Peck.

Pileus 2–9 cm. broad, globose when young, the margin resting on the bulb of the stipe, soon becoming truncate-subconic and at length broadly convex, the disc sometimes becoming slightly depressed, the margin deflexed and exceeding the lamellae, surface at first covered with a very thin, whitish film of the universal veil which soon becomes broken up leaving minute flecks over the central portion and quickly disappearing elsewhere, the cuticle dry, appressed fibrillose, subsquamulose toward the margin, "vinaceous rufous" to "vinaceous buff" (dull vinaceous to vinaceous gray), gradually becoming radiately rimose and exposing the white flesh toward the margin; flesh white, sometimes tinged vinaceous gray near the cuticle under the disc, cottony fibrillose, 3–7 mm. at the thickest point, very thin at the deflexed margin; lamellae white, sometimes faintly yellowish, close, unequal, not forking, subventricose, broadest (4–7 mm.) near the front, rounded behind, free but proximate, edges minutely fimbriate; stipe 2.5–5 cm. long, 4–8 mm. thick above, enlarged downward either gradually or abruptly to a distinct bulb 10–17 mm. thick which is clavate to globose, pure white over all, white within, surface glabrous to slightly fibrillose-floccose (as viewed under a lens), solid but soon stuffed with a white pith, base furnished with numerous white rhizomorphs; annulus inferior to median, membranous, white, about 2 mm. wide, sometimes adhering to the margin of the pileus as membranous patches but usually persistent on the stipe.

Spores white in mass, 7.2–9.6 × 4.2–4.8 μ, chocolate brown in iodine, smooth, subovoid to ellipsoid; basidia clavate, 16–18 × 6 μ, 4-spored; cheilocystidia abundant, 26–43 × 7.2–10–8 μ, clavate to subventricose or broadly fusoid; gill trama homogeneous, of loosely interwoven hyphae; pileus trama loosely interwoven also, cuticle composed of elongated, slender, appressed, narrow (3–5 μ) hyphae with the pigment intracellular, no clamp connections seen.

Gregarious on soil in a lath-house of Miss Kate Walker, Santa Barbara, Calif., July 12 to Dec. 22, 1941 (Rea *968*, *988*, *996*, *1001*, *1013*, *1017*, *1070*). Specimens have been deposited in Univ. Mich. Herb., N. Y. State Mus., and Missouri Bot. Gard. Specimens were also sent by Miss Walker to Miss Elizabeth E. Morse at Berkeley, Calif.

Observations: The type collection was made in Missouri and the species has not since been reported. The types at Albany

and part of the same collection at St. Louis, which were kindly lent us for examination, include only small specimens with slender stipes such as were collected early in the season at Santa Barbara. These are connected by intermediate stages with the much larger and the more robust plants that came up at the height of the season. Comparing the dried specimens, the cuticle of the type is "hair brown" instead of "light cinnamon-drab" as in the Santa Barbara collections, but this difference is slight and may easily have been caused by different methods of preparation. The spores of the type measure 6–7.5 × 4–4.5 μ but were otherwise similar to those of Rea *988*. The cheilocystidia are identical in both. The only possibly significant discrepancy is in the spore size. We have encountered as much variation in other species and we believe it should be disregarded here. The diagnostic characters are: the fibrillose nature of the cuticle and the intracellular pigment of its hyphae, the vinaceous color, bulbous and typically glabrous stipe and medium sized spores (6.5–9 μ).

We first encountered the species in 1936, but the most luxuriant fruiting occurred in August, 1941. More than a hundred carpophores in all stages of development were studied at that time. At first the globose pileus rest directly on the bulb of the stipe which is then broader than the cap. The early elongation of the stipe is above the partial veil, thus accommodating the growth in height of the pileus and causing the annulus to form just above the bulb. At this stage the shape of the pileus is distinctive. It is usually about 2 cm. high but 2.8 cm. broad just above the inflexed margin and slopes upward to the truncate or slightly depressed disc. As it matures it becomes broadly convex. Not all of the mature specimens become rimose and a few white flecks of the universal veil may frequently be found on the marginal area as well as on the disc. In many cases the later elongation of the stipe is not restricted to the part above the annulus, in which case the bulb becomes appreciably thinner and the annulus is eventually raised to a median position.

L. Glatfelteri should not be regarded as a hothouse species. The lath-house gave protection from direct sun and moderated the temperature. These conditions together with fairly abundant watering produced luxuriant crops from July to December.

During these months the chaparral from which the leaf mold came would not be expected to produce agarics because of the entire absence of rain. As yet we have not found the species fruiting in this area during the rainy season.

Lepiota lutea var. **aurantio-floccosa** var. nov.

Pileus 3–5 cm. latus, siccus, aurantio-floccosus; lamellae pallide luteae; stipes clavatus, deorsum aurantio-floccosus; sporae 8–11 (12) × 5–5–7 μ.

Pileus 3–5 cm. broad, at first ovate, at length plane, obtuse, striate for about 5 mm. in from the margin, minutely fibrillose-floccose, ground color "Martin's yellow" to "picric yellow," covered at first with orange to reddish brown floccose scales from the universal veil, the disc fibrillose-tomentose and reddish brown, near the margin the scales scattered and orange in color; flesh membranous, whitish or pale yellowish; lamellae close, white with a faint yellow tint, unequal, subventricose, 3–4 mm. broad, rounded behind, free and at length remote, edges minutely fimbriate; stipe 5–8 cm. long, 2–3 mm. thick above, gradually incrassate below into a clavate bulb about 6 mm. thick, pallid at the apex, concolorous with the pileus below, floccose (especially below the annulus), the bulb flecked with orange or reddish fragments of the universal veil, white or yellowish within, solid in the bulb, hollow above; annulus more or less fugacious, white with a yellow margin flecked with flocci of the orange universal veil.

Spores hyaline, ovoid, 8–11 (12) × 5.5–7 μ, apex truncate, smooth, dark chocolate in iodine; basidia 4-spored, subcapitate, 17–20 × 7–9 μ; paraphyses well differentiated, 18–22 × 10–14 μ, saccate and thin-walled; pleurocystidia none; cheilocystidia 48–64 × 9–12 μ, cylindric, subventricose or obtusely fusoid ventricose, thin-walled, abundant; gill trama loosely interwoven, homogeneous; pileus trama loosely filamentose, cuticle of pileus of more or less radially arranged fibrils of varying thickness, universal veil remnants of filamentose, branched, intricately interwoven hyphae 5–11 μ in diameter.

On humus in a greenhouse of Miss Kate Walker, Santa Barbara, Calif., Aug. 26, 1942. In Herb. Paul and Marian Rea (*1117*), also in the Univ. of Mich. Herb.

Observations: In the dried condition the universal veil remnants form a more or less dark avellaneous, floccose covering over the disc and are segregated into patches toward the margin. Thus

it appears their change in color in drying is distinctive. The plant is so similar to *L. lutea* in all characters except the color of the floccules that it is referred to that species as a variety. We have compared it with abundant collections of typical *L. lutea* which grew in the same greenhouse in 1941 and 1942.

We thought for a time that our plant might be *L. sulphurina* (Clem.) Sacc. The type of that species could not be found at Nebraska, but we were fortunate to receive from Dr. Clements authentic specimens collected by Edward Bessey on the ground at Lincoln, Neb., Aug. 19, 1895 (now *1265* in the Rea herbarium). We find these clearly distinguished from the various forms and varieties of *L. lutea* by narrower paraphyses (only 3–6 μ thick) which are not vesiculose at the time of spore discharge, and by the lack of a truncate apex on the spores (observed under oil). Kauffman thought that *L. sulphurina* was more likely an *Amanita* but it has a loosely floccose, homogeneous gill trama which proves conclusively that it is not in that genus.

Melanoleuca Lewisii sp. nov.

Pileus 4–8 cm. latus, convexus mox planus, glaber, viscidus, albidus dein pallide luteus; lamellae albidae, adnexae, latae, confertae; stipes 3–6 cm. longus, 1 cm. crassus, subbulbosus, fibrillosus, albidus; sporae 6–8.5–4–5 μ.

Pileus 4–8 cm. broad, convex to plane, obtuse, neither umbonate nor depressed, margin more or less undulating, not striate, not inflexed in drying, glabrous, slimy viscid when moist, pure white when young and fresh, in age becoming bright lemon yellow especially on the margin, when dried either whitish or pale yellowish; flesh white, 3–5 mm. thick in the disc, thin toward the margin (1–3 mm.), odor none, taste mild; lamellae pure white, broad, 8± mm., equal to subventricose, rounded behind, deeply emarginate adnexed but with a decurrent tooth, crowded, many lamellulae present, some anastomosing near the margin to give a pseudo-forking effect, edges undulating and white but becoming yellowish in drying; stipe usually short, 3–6 cm. long, stout, 1± cm. thick, sometimes compressed and 8 × 13 mm., slightly flared at apex, base sometimes subbulbous, white, fibrillose, spongy and white within but soon hollowed by grubs.

Spores white in mass, 6–8 (8.5) × 4–5 μ, ellipsoid, covered with strongly amyloid small warts; basidia clavate, 4-spored, 30–36 × 8–9 μ; pleuro- and cheilocystidia similar and scattered, fusoid-ventricose, the apex usually encrusted, 46–64 × 9–14 μ,

hyaline; gill trama subparallel to interwoven, the cells 6–22 μ in diameter and the length equally variable, not amyloid; pileus trama homogeneous beneath a thick, somewhat gelatinous pellicle of hyphae 4–7 μ in diameter, not amyloid, no clamp connections seen.

Gregarious to subcespitose, near Santa Barbara, California. First collected by Edward R. Lewis Feb. 18, 1939 (Rea *113*), under chaparral at about 1000 ft. elevation (2 specimens only); later by Paul and Marian Rea under Monterey pine nearer sea level Mar. 2, 1940 (Rea *399*), and Dec. 31, 1941 (Rea *1077*). Parts of both the later collections are in the Univ. Mich. Herb. Collection *1077* is designated as the type because it includes more specimens and affords the best basis for the description. To Mr. Lewis we are indebted not only for discovery of this species but for many other interesting collections in 1939 and 1940.

Observations: Although the great majority of the species of *Melanoleuca* (sensu Patouillard) have a very similar stature and appearance, caused by the crowded narrow gills and strict, more or less longitudinally striate stipes, this alone cannot be relied upon to distinguish the genus. *M. Lewisii* resembles *Hebeloma crustuliniforme* in stature and, until a microscopic examination is made, one would not suspect it of belonging in *Melanoleuca*. The spores, cystidia, and lack of clamp connections, however, leave no doubt as to its proper genus. The stature, white color throughout when young, viscid pileus and yellowish tints in age distinguish it as a species. It does not appear to be very similar to any of the known species.

MELANOLEUCA REAI Singer, Cavanillesia **7**: 6. 1935.

Pileus 2–6.5 cm. broad, campanulate to broadly convex or almost plane, sometimes with a small umbo, creamy with brown and sordid gray tints, dull, chalky, becoming shining upon drying, the slightly undulating margin inrolled when young; flesh thin except in the disc, creamy white, odor none, taste mild; lamellae broad, 5–8 mm., broadest in the midportion, sinuate-adnate, sometimes with a decurrent tooth, whitish, close, unequal; stipe 4–5 cm. long, up to 7 mm. thick, sometimes slightly eccentric, equal above the subbulbous base, pruinose toward the apex, fibrillose-striate below, with white basal tomentum, stipe

tissue continuous with that of pileus but of a different texture, stuffed and sordid white within.

Spores pale creamy in mass, hyaline under the microscope, 8.4–9 × 6–7.2 μ, broadly ovoid, with very small, scattered, strongly amyloid warts over the surface; basidia 4-spored, 28–32 × 8–10 μ; pleurocystidia none; cheilocystidia inconspicuous and scattered to very rare, apices sometimes slightly encrusted, 28–42 × 5–6 μ; gill trama subparallel to interwoven, not amyloid; pileus trama homogeneous, the surface hyphae 5–9 μ in diameter, interwoven, clamp connections not found.

On a lawn, Montecito Country Club, Santa Barbara, California. Collected by Paul and Marian Rea Sept. 26, 1939 (Rea *217*), and Nov. 16, 1939 (Rea *249*). Part of both collections are in Univ. Mich. Herb.

Observations: The cream-colored spores, lack of a distinctive taste or odor, the very slender cheilocystidia, and the tendency of the stipe to be eccentric distinguish this species. *M. Reai* is the species described by C. Rea [4] under the name *Tricholoma subpulverulentum* (Pers.) Fries. Two discrepancies exist between the description of *T. subpulverulentum* and the California collections. The spores of the latter are distinctly larger and there is a slight tendency for the stipe to be eccentric. These characters may indicate a distinct western species, but for the present it appears best to interpret them as variants within *T. subpulverulentum*. Local races differing in spore size were found in *Leucopaxillus* for *L. giganteus* by Singer & Smith. We have observed that in many species of *Melanoleuca* there is a tendency for the stipe to be slightly eccentric, and consequently hesitate to place much emphasis on that character unless it is quite pronounced and constant. The important characters are the slightly yellowish spores and the somewhat pulverulent appearance of the pileus.

[4] Rea, Carlton, British Basidiomycetae. 1922.

THREE HYPHOMYCETES THAT CAPTURE NEMATODES IN ADHESIVE NETWORKS

CHARLES DRECHSLER [1]

(WITH 5 FIGURES)

In several previous papers (**4, 5, 6**) descriptive treatment was given to 22 interrelated hyphomycetes found subsisting by the capture and destruction of eelworms infesting transparent agar plate cultures started from diseased rootlets or from other decaying vegetable materials. Similar treatment is devoted herein to 3 additional fungi of like biological habit and manifestly belonging to the same predaceous series. Capture of eelworms is accomplished, in all 3 fungi, by means of adhesive bail-like hyphal loops, which, as in allied forms, may occur singly, or may be compounded into networks of variable intricacy. Two of the fungi are referred to *Arthrobotrys*, one being presented as a new variety, while the other is identified with a long-established though somewhat unfamiliar species of that genus. The third fungus is described as a new species of *Dactylaria*. In relation to a subsidiary spore form apparently connected with the new species, preliminary discussion is devoted to a delicate *Trichothecium* found producing stalked adhesive knob-cells.

A VARIETY OF ARTHROBOTRYS CLADODES WITH DISTINCTLY PEDICELLATE ELONGATED CONIDIA

A maizemeal-agar plate culture which after being permeated with *Pythium* mycelium had been further planted with small quantities of leaf mold collected near Beltsville, Md., early in October 1936, showed on subsequent examination numerous eelworms being captured and consumed by a small *Arthrobotrys*

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having the general aspect of *A. superba* Corda or *A. cladodes* Drechsl. (**4**, p. 450–464). Since these two species, unlike most hyphomycetes of similar predaceous character, usually can not be distinguished well in nematode-infested agar cultures owing to the frequent failure of their conidiophores to develop beyond a simple monocephalous condition, the fungus was isolated by removing some of its conidia aseptically from their supporting hyphae to sterile agar in Petri dishes. When the plate cultures started in this way had grown for a few weeks, they showed little tendency toward the prolific uniaxial development of successive conidial clusters so characteristic of *A. superba*, but revealed instead a slower, more moderate multiplication of larger conidial heads through lateral branching of the conidiophores. Although with respect to sporulating habit the fungus thus agreed closely with the several strains of *A. cladodes* then familiar to me, it displayed readily noticeable differences in the more elongated shape and consistent pedicellation of its conidia, as well as in its production of more or less indurated resting bodies. Because of these differences the fungus was excluded from consideration at the time the specific description of *A. cladodes* was drawn up. It made its appearance more recently in some maizemeal-agar plate cultures started from decaying pansy roots collected in Mt. Rainier, Md., on May 21, 1943.

Grown in pure culture on Petri plates of maizemeal agar the fungus produces a commonplace mycelium composed of colorless branching filamentous hyphae, septate at moderate intervals, with the aperture of each cross-wall guarded on both sides by "Woronin bodies." When sizable slabs of agar medium newly permeated with young mycelium are removed to agar plate cultures abundantly infested with actively motile eelworms, hyphal bails and anastomosing networks are formed everywhere in the transferred slabs, and later are also produced at variable intervals along the rangy filamentous hyphae that grow out rather sparingly in all directions from the slabs. The networks often become 4 or 5 times more extensive than the examples illustrated in figure 1, *A*, *B*. They closely resemble the networks of *Arthrobotrys superba* and *A. oligospora* Fres. with respect to the width of their anastomosing hyphal elements, as well as

with respect to the size of their meshes. The resemblance extends also to manner of operation: relatively small, weak nematodes are often held merely through adhesion, while capture of larger and more energetic eelworms usually requires, besides, some degree of enmeshment (FIG. 1, *C*). Perforation of the animal's integument soon ensues through intrusion of a delicate process at some place where the network makes intimate contact with the prey. Often when enmeshment is rather loose, one of the hyphal elements nearest to the animal may give rise to a short stout branch that grows firmly against the integument and then narrowly penetrates it (FIG. 1, *C*). After penetration is accomplished the fungus produces within the integument a globose enlargement which soon puts forth assimilative hyphae to permeate the animal's body from head to tail. If the integument is penetrated in several places, a corresponding number of globose enlargements are usually intruded, all of them generally sharing in the invasion of the prey, though not necessarily in equal measure.

As invasion proceeds the animal's musculature and organs undergo globulose degeneration, the softer parts disintegrating more rapidly than the firmer tissues of the oesophagus and valve. During the period when the newly extended assimilative filaments are most active in appropriating contents of the prey, they likewise contain numerous globules, which, however, are generally smaller than those formed directly from the tissues of the nematode. Later, as the animal's substance nears exhaustion, the globules of the haustorial system diminish markedly. Since the assimilative filaments never grow out through the enveloping integument, nor give rise to erumpent branches, it is clear that the materials absorbed by the fungus are transferred backward into the hyphal loop or network from which the invasion began. As the last remnants of degenerating flesh disappear, the contents of the assimilative filaments begin to share in the backward movement; with the result that apart from the indurated spicules present in male specimens, the empty collapsing integument of the eelworm eventually surrounds only the equally empty membranous remains of the haustorial system.

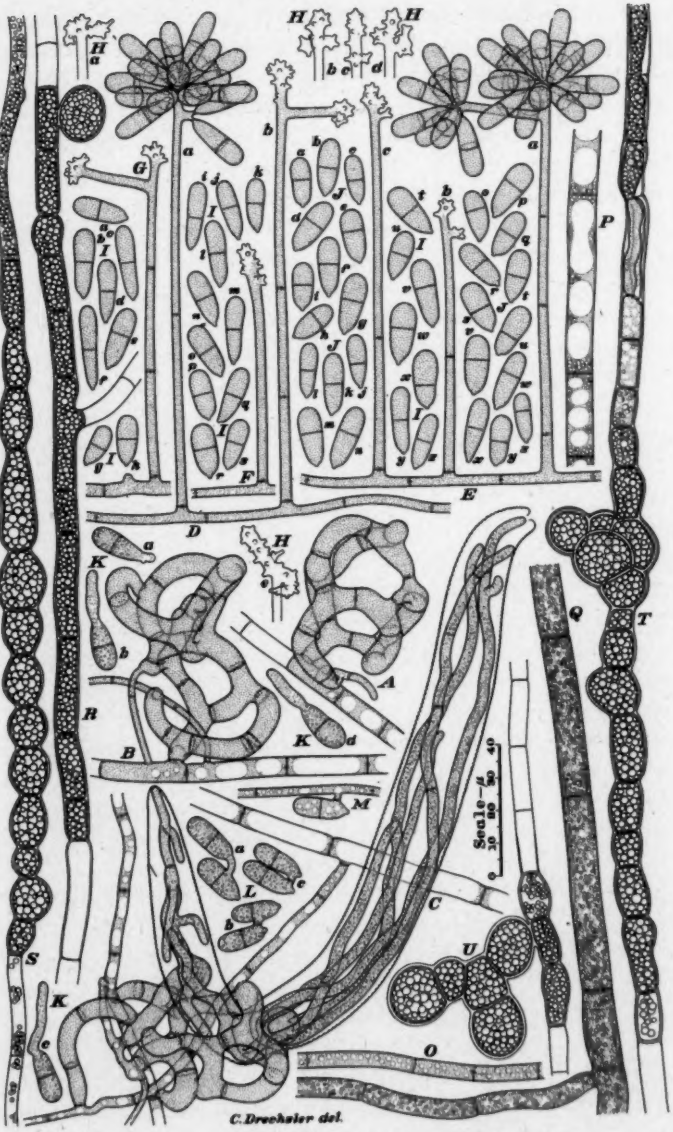

FIG. 1. *Arthrobotrys cladodes* var. *macroides*.

The conidial apparatus produced in nematode-infested cultures is ordinarily too sparse to be seen with the naked eye. However, in pure culture on maizemeal-agar plates, the fungus sporulates more freely; so that after about 5 days of growth a mycelium will usually reveal a delicate turf near its center. The conidiophores making up this downy turf closely resemble those formed in eelworm-infested cultures, since like the latter they commonly measure only 3 to 4 μ in width, and bear at the tip a bristling cluster of conidia (FIG. 1, *D*, *a*) together sometimes with a subsidiary cluster at the tip of a subapical spur (FIG. 1, *E*, *a*). While the clusters are mostly borne 110 to 150 μ above the surface of the substratum, relatively short conidiophores may bear their conidial heads at heights less than 100 μ (FIG. 1, *E*, *b*) or even less than 75 μ (FIG. 1, *F*). In its denuded condition the sporiferous tip of the main hypha (FIG. 1, *E*, *b*, *c*; *F*), as also the tip of the subapical spur (FIG. 1, *D*, *b*; *G*)—where a spur is present—reveals fairly pronounced, truncate denticulations. Often the sporiferous tip is found irregularly expanded or lobed in a manner to afford increased spatial capacity for attachment of conidia (FIG. 1, *H*, *a–e*).

During their earlier development in a Petri-plate culture conidiophores evidently arise only from filamen[illegible]strate on the surface of the substratum, but after 2 or 3 w[illegible]icted areas often become covered with whitish aerial wef[illegible]n numerous conidiophores commonly arise from aerial [illegible]nts. These conidiophores, on declining toward the substratum, or even while still in an erect posture, frequently branch out near the base to give rise to secondary conidiophores; and the same process may be repeated several times. In instances where the older conidiophores remain more or less erect, those of secondary, tertiary, or quaternary origin may show rather pronounced curvature. Conidiophores resulting from the somewhat indeterminate development usual in aerial wefts often attain lengths varying between 200 and 300 μ, and basal widths between 4 and 6 μ.

As has been mentioned the conidia of the present fungus (FIG. 1, *I*, *a–e*; *J*, *a–z*) would seem appreciably longer and narrower than those produced in the cultures on which the description of *Arthrobotrys cladodes* was based. The relevant metric

data given in the diagnosis below were obtained by measuring 200 specimens taken at random in microscope mounts prepared from abundantly sporulating material. Expressed as the nearest integral number of microns, the values for length were distributable thus: 13 μ, 1; 14 μ, 2; 15 μ, 15; 16 μ, 29; 17 μ, 47; 18 μ, 48; 19 μ, 34; 20 μ, 14; 21 μ, 8; 23 μ, 1; 26 μ, 1; while the values for width were distributable as follows: 5 μ, 5; 6 μ, 102; 7 μ, 84; 8 μ, 9. Aside from dimensional differences the conidia diverge from those of *A. cladodes* in being drawn out at the proximal end into a distinct basal protrusion. Germination ensues very readily, much as in other members of the predaceous series. Often a germ tube is put forth from the proximal end (FIG. 1, *K*, *a–d*), but at other times, especially when anastomosis with another conidium (FIG. 1, *L*, *a–c*) or with a mycelial filament (FIG. 1, *M*) takes place, germination and vegetative union may be effected elsewhere than at the base.

On prolonged aging many of the submerged hyphae in maize-meal-agar cultures of the fungus gradually increase in width (FIG. 1, *O*), some becoming conspicuously vacuolate (FIG. 1, *P*), others becoming filled with numerous minute globules (FIG. 1, *Q*). Eventually most of the granular and globuliferous contents are collected in portions of filament consisting usually of 5 to 20 indurated segments. The segments may retain a cylindrical shape (FIG. 1, *R*), or, again, they may become more or less prominently inflated (FIG. 1, *S*). A branched arrangement of the segments is by no means uncommon (FIG. 1, *R*, *T*, *U*). Manifestly the groups of cells make up resting bodies of the same type as those produced abundantly in maizemeal-agar cultures of the predaceous species I have recently described as *Dactylella heterospora* (**6**, p. 339–349). Their resistance to desiccation would seem more than commensurate with the moderate induration suggested by their faintly yellowish coloration and the rather meager thickening of their walls. Like the chlamydospores of *Arthrobotrys oligospora* and of the two allied retiary species I presented earlier under the binomials *A. conoides* (**4**, p. 473–477) and *Dactylaria thaumasia* (**4**, p. 518–523), they remained alive in maizemeal-agar cultures fully 4 years old, although during the

last 30 months of storage the medium was in a completely air-dry horny state (6, p. 346).

The fungus appears to merit recognition as a distinct variety; and is accordingly described under a varietal term meaning "of long form."

Arthrobotrys cladodes var. **macroides** var. nov.

Mycelium effusum; hyphis hyalinis, septatis, primo plerumque 2–7 μ crassis, postea usque 11 μ crassis, laqueos tenaces arcuatos vel circulares in reticula saepe conjunctos evolventibus; his laqueis vermiculos nematoideos tenentibus, deinde integumentum cuiusque animalis perforantibus, tuber debilitans vel mortiferum intrudentibus, hyphas intus evolventibus quae carmen exhauriunt. Hyphae fertiles hyalinae, erectae, septatae, simplices vel aliquid ramosae, plerumque 75–300 μ altae, basi 2–6 μ crassae, subter apicem 1.5–2.5 μ crassae, apice dilatatae vel coralloideae, ibi ex denticulis obtusis 5–30 conidia in capitulum confertum ferentes. Conidia hyalina, elongato-ellipsoidea vel elongato-obovoidea, apice rotundata, basi obtuse pedicellata, 13–26 μ (saepe circa 17.6 μ) longa, 5–8.2 μ (saepe circa 6.4 μ) crassa, loculis duobus inter se nunc paene aequalibus, nunc inaequalibus, loculo superiore 5.5–13.4 μ (saepe circa 8.4 μ) longo, loculo inferiore 6.4–12.4 μ (saepe circa 9.2 μ) longo. Corpora perdurantia intra matricem orta; flavidula, protoplasmatis valde guttulosi repleta, modo simplicia modo paulum ramosa, vulgo 50–250 μ longa, in 5–20 cellulis saepius consistentia, cellulis vulgo 7–35 μ longis, 7–20 μ crassis.

Mycelium spreading; vegetative hyphae hyaline, septate, at first varying in width mostly from 2 to 7 μ, some later becoming wider and then occasionally attaining a diameter of 11 μ, in their young condition often, especially in the presence of nematodes, giving rise to sturdy hyphal bails and loops, which, though discrete in the beginning, are later frequently compounded into more or less extensive networks; the bails and networks capturing nematodes through adhesion and enmeshment, then perforating the integument of each captured animal and intruding one or more globose mortiferous excrescences from which are extended assimilative hyphae to appropriate the fleshy contents. Conidiophores hyaline, erect, septate, simple or somewhat branched, mostly 75 to 300 μ high, 2 to 6 μ wide at the base, 1.5 to 2.5 μ wide below the tip which frequently is somewhat widened or irregularly lobed and on which are borne 5 to 30 conidia in capitate arrangement. Conidia hyaline, elongate ellipsoidal or elongate obovoid, rounded at the distal end, provided with a distinct apiculum-like basal prominence at the proximal end, 13 to 26 μ, mostly 15 to 21 μ (average 17.6 μ) long, 5 to 8.2 μ (average 6.4 μ) wide, divided by a cross-wall at the middle, above the middle, or below the middle, the upper cell 5.5 to 13.4 μ

(average 8.4 μ) long, the lower cell 6.4 to 12.4 μ (average 9.2 μ) long. Resting bodies formed tardily in the substratum, faintly yellowish, filled with pronouncedly globuliferous contents, mostly intercalary, simple or somewhat branched, commonly 50 to 250 μ long, usually composed of 5 to 20 segments measuring individually 7 to 35 μ in length and 7 to 20 μ in width.

Capturing and consuming eelworms up to 600 μ long referable to species of *Acrobeloides*, *Cephalobus*, *Plectus*, *Rhabditis* and other genera it occurs in decaying roots of *Viola tricolor* L. and in leaf mold in Maryland.

ARTHROBOTRYS ARTHROBOTRYOIDES (BERLESE) LINDAU

From time to time examination of agar plate cultures wherein nematodes were being destroyed by predaceous hyphomycetes has disclosed sparsely scattered conidiophores of robust stature, bearing aloft individually a terminal cluster of conidia which with respect to their largish dimensions appeared rather similar to the conidia of *Arthrobotrys oligospora*, but which with respect to their lesser tapering and nearly equal partitioning more nearly resembled those of *A. superba* or *A. cladodes*. Because of its ambiguous morphology the conidial apparatus in question was excluded from consideration in my treatment of the 3 species mentioned. More recently the fungus here concerned was isolated from leaf mold gathered in deciduous wood near Presque Isle, Me., on Oct. 1, 1941, as well as from leaf mold gathered in deciduous woods near Fairfax, Va., on Nov. 10, 1942.

In pure culture on maizemeal agar the fungus, like most other hyphomycetes of similar biological adaptation, grows rather rapidly to form a dense mycelium devoid of any modification for capture of animals. When a sizable slab permeated with young hyphae is removed from a growing culture to an agar plate culture infested with nematodes, adhesive hyphal bails and networks (FIG. 2, *A; B, a, b*) soon come to light, first appearing promiscuously throughout the transferred slab, and later developing at intervals along the straightforward, rangy filaments extended sparsely in all directions into the adjacent substratum. As might be expected the retiary apparatus promptly begins to capture some of the eelworms whose presence evoked its formation,

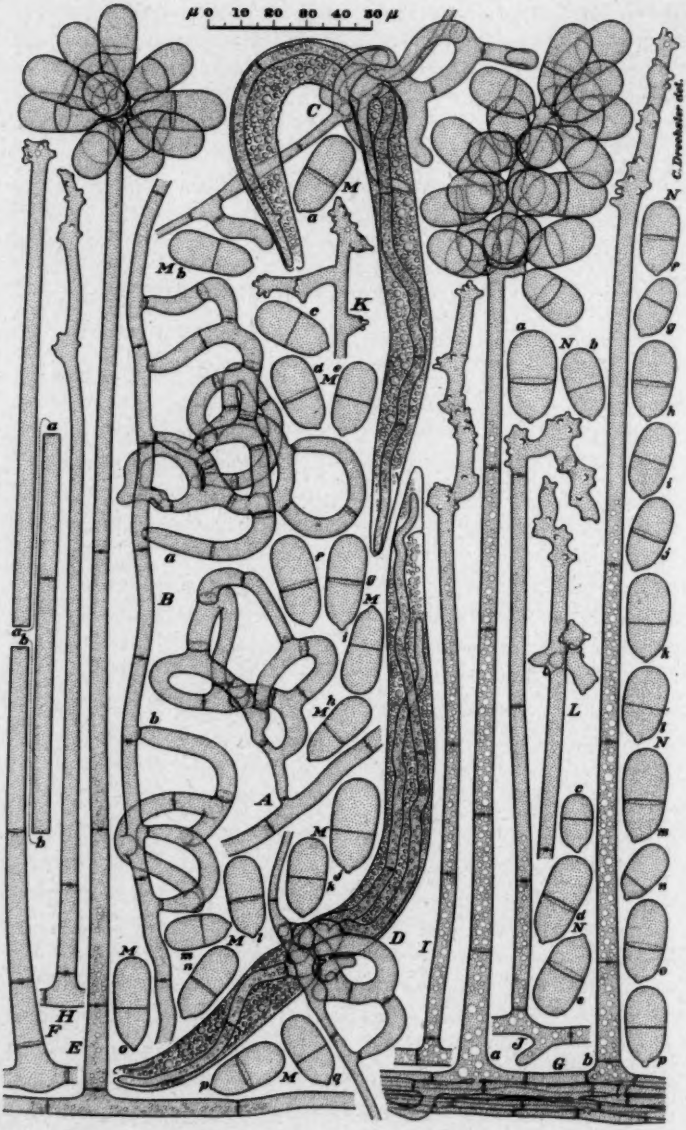

FIG. 2. *Arthrobotrys arthrobotryoides.*

capture being effected through adhesion and enmeshment. Before long the integument of each hapless animal is narrowly perforated by a delicate bud put forth from an enveloping (FIG. 2, *C*) or adjacent hyphal element; or, often, especially in instances where envelopment is loose at the beginning, from one or more short branches that grow firmly against the prey (FIG. 2, *D*). After being disabled from rapid intrusion of one (FIG. 1, *C*) or more (FIG. 1, *D*) bulbous excrescences, the eelworm is invaded from head to tail through the longitudinal extension of assimilative hyphae. Progressive globulose degeneration of musculature and fleshy organs, absorption of the resulting products by the assimilative hyphae, transfer of appropriated or elaborated materials backward through these hyphae into the external parts of the fungus, and withdrawal of protoplasm from the assimilative filaments—all these processes ensue in the same sequence as in allied forms.

When the fungus thus obtains its nourishment from eelworms rather than from the mass of substratum infested by them—presumably the infested substratum ordinarily becomes unusable as a food supply because of foulness brought on by heavy bacterial contamination—it gives rise to a relatively sparse array of conidiophores. These conidiophores, as has been intimated, are of robust stature, usually attaining a height of 300 to 450 μ before they produce from 5 to 10 conidia in a single terminal cluster (FIG. 2, *E*, *F*). Often they measure 5.5 to 8 μ, or even as much as 9 μ, in basal diameter, while varying from 4 to 5 μ in width some distance below the apex. When fully developed they frequently contain 4 or 5 or 6 cross-walls. After the conidia have fallen off, the somewhat expanded tip is revealed as being beset with bluntly truncate sterigmatic protuberances (FIG. 2, *F*).

When the fungus grows in pure culture, so that the more abundant nourishment of the substratum itself can be utilized, vegetative development and spore production are much more luxuriant. Under moist conditions aerial filaments often cohere longitudinally, and thereupon, as in *Arthrobotrys oligospora*, where similar hyphal fasciation was noted by Matruchot (**10**), become united through multiple anastomoses to form coarse mycelial strands from which conidiophores are given off erectly (FIG. 2,

G, a, b) or in somewhat promiscuous radial arrangement. Although some conidiophores formed here are fully as stout as those formed on nematode-infested materials, others are slenderer (FIG. 2, *H*), not a few measuring only from 4 to 5 μ in diameter (FIG. 2, *I, J*). Many of the conidiophores here produce a cluster of conidia at a height of 200 μ (FIG. 2, *H*), or even at substantially lesser heights (FIG. 2, *I, J*). If evaporation is reduced to prevent early desiccation the conidiophores continue to elongate distally and to form additional conidia, though not on a scale as spectacular as in cultures of *A. oligospora* and *A. superba* that have benefited from similar treatment. Apart from its lesser prolongation the extended conidiiferous spike here is marked by less distinct separation into a series of spore clusters. For although localization of conidial attachments at nodes is at times readily recognizable (FIG. 2, *H*), no less often a rather haphazard arrangement of sterigmatic prominences along a crooked (FIG. 2, *I, J*) or irregularly branched rachis (FIG. 2, *K, L*) denotes botryose aggregation rather than seriate clustering.

Conidiophores of the fungus can be distinguished with moderate certainty from those of *Arthrobotrys oligospora* even when, as usually in nematode-infested cultures, they are bearing aloft only between 5 and 10 conidia in a simple head (FIG. 2, *E*); the capitate arrangement here being noticeably more open with respect to the distal portions of the spores. The looser distal spacing can not be considered a fortuitous feature, but must be held to result from the shape of the conidia making up the cluster, since these, as a rule, taper less markedly from apex toward base than conidia of *A. oligospora*. Because of this lesser tapering, and because, further, their single cross-walls are generally placed in more nearly median positions than in *A. oligospora*, the conidia of the present species, on the whole, show less pronounced inequality in size between the larger distal cell and the smaller proximal cell (FIG. 2, *M, a–q; N, a–p*). In some conidia the 2 cells appear of nearly equal volume, and occasionally, indeed, the lower cell is larger than the upper one (FIG. 2, *N, c, g*).

Spore morphology, as in allied species, is strongly affected by the environmental conditions that attend development. Owing to their relatively large dimensions, and to the relatively high

degree of uniformity in size, shape, and septation revealed by them, the conidia produced in nematode-infested cultures at a temperature of about 20° C. (FIG. 2, *M*, *a–q*) may perhaps be regarded as most distinctive of the fungus. When development takes place at 20° C. in pure culture on a suitable medium like maizemeal-agar (FIG. 2, *G*, *a*; *N*, *a–p*), almost equal uniformity of size, shape, and septation prevails, especially if the substratum and sporiferous layer remain free of troublesome deposits of water. Measurements of 100 conidia selected at random in equal numbers from nematode-infested and pure cultures, which in both instances had developed at 20° C., gave values for length, expressed as the nearest integral number of microns, with a distribution as follows: 17 μ, 1; 18 μ, 2; 19 μ, 2; 20 μ, 4; 21 μ, 8; 22 μ, 3; 23 μ, 13; 24 μ, 16; 25 μ, 16; 26 μ, 14; 27 μ, 9; 28 μ, 6; 29 μ, 4; 30 μ, 2; and values for greatest width distributable thus: 10 μ, 6; 11 μ, 19; 12 μ, 37; 13 μ, 25; 14 μ, 11; 15 μ, 1; 16 μ, 1. The measurements yielded averages of 24.4 μ and 12.1 μ for length and width, respectively; and averages of 13.2 μ and 11.2 μ for length of upper cell and length of lower cell, respectively. In 85 of the 100 conidia the upper cell was clearly longer than the lower one; in 8 the two cells were of about equal length; in the remaining 7 the basal cell (including the basal prominence) was longer than the upper cell, though, owing to its usually somewhat smaller diameter, not always of greater volume.

The conidia (FIG. 3, *A*, *a–z*; *B*, *a–j*) developed in pure culture on maizemeal-agar at 28 to 32° C., a usual daily range of indoor temperatures near Beltsville, Md., include a large proportion of short ovoid and ellipsoidal specimens. Very often the plump spores of such origin reveal no cross-wall, apparently remaining continuous in their definitive state (FIG. 3, *B*, *a–j*). In septate specimens the two cells appear frequently of nearly equal size, though, on the whole, the upper cell here, too, would seem slightly to exceed the lower one in volume (FIG. 3, *A*, *a–z*).

In the morphology of its conidial apparatus the fungus agrees rather well with the illustrated description wherein more than half a century ago a hyphomycete found occasionally on moist rotten mulberry (*Morus alba* L.) wood at Padua in Northern Italy was presented by Berlese (1, 2) as a new variety, *arthrobo-*

tryoides, of *Cephalothecium roseum* Corda. The conidial dimensions given by Berlese, 20 to 22 μ for length and 9 to 10 μ for width, though somewhat smaller than the dimensions I consider most characteristic of my cultures, are yet very frequent when my cultures are grown at summer temperatures. Berlese's characterization of the conidia produced by his fungus as elongate-ovoid, uniseptate, rounded distally, often obtusely apiculate at the base, and with the upper cell only slightly more distended than the lower, applies accurately to the conidia produced by mine. Taken collectively, his figures, moreover, show very much the same approximation to equality in size of the two conidial segments that comes to light in my material. If, perhaps, in general, these figures show slightly greater constriction at the septum than is commonly evident in my cultures, or, for that matter, than might be justified by the term "vix" in Berlese's diagnosis, it may be profitable to recognize that at the small magnification employed a really minute feature could not have been represented clearly without some exaggeration.

As the Italian fungus bore its conidia on denticulations constantly present on the expanded apex of the erect fertile hypha, and sometimes present likewise on an intercalary node below the apex, Berlese recognized its resemblance to *Arthrobotrys superba*. That he nevertheless assimilated it to *Cephalothecium roseum* may very probably be attributed to the persistent misunderstanding through which, as has been related earlier (**4**, p. 469–471), *Arthrobotrys* was long confused with *Trichothecium* and *Cephalothecium;* though this misunderstanding would hardly seem to account for his very puzzling interpretation of *Cephalothecium* as a more developed form (una forma più sviluppata) of *Arthrobotrys*. Four years later, Matruchot (**10**), after distinguishing anew the basipetal development of conidia in *C. roseum* from the truly capitate sporulation of *Arthrobotrys*, pronounced Berlese's fungus to be beyond doubt *A. oligospora*.

The transfer of Berlese's fungus to *Arthrobotrys* can be viewed with more satisfaction than its identification with *A. oligospora*. Since Matruchot's text gives no ground for supposing that he had received authentic material from Berlese, the identification may be presumed to have been made solely from Berlese's description

and figures, and these, as has been intimated, appear better applicable to a fungus specifically alien to the one described by Fresenius. Rather curiously, Matruchot may actually have dealt at first hand with the same organism as Berlese, for his

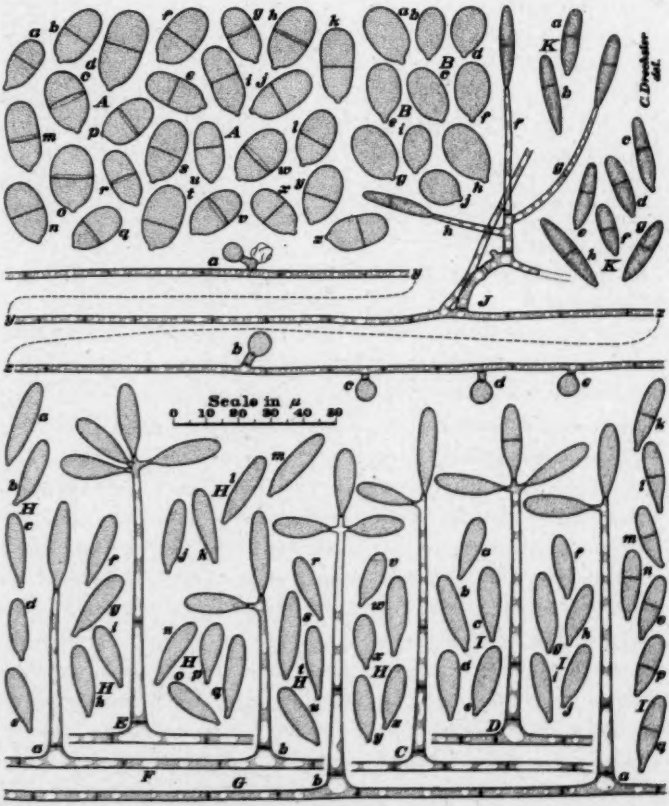

FIG. 3. *A, B, Arthrobotrys arthrobotryoides; C–I,* small hyphomycete resembling subsidiary sporlating stage of *Dactylaria psychrophila; J–K,* predaceous knob bearing fungus with a delicate *Trichothecium* stage.

illustrated account of the fungus he formally denominates as *A. superba* Corda var. *irregularis* Matr.—his other designations "la forme *irregularis* Matruchot" (**10**, p. 74) and "*Arthrobotrys irregularis*" (**10**, p. 109) are mentioned casually—presents fea-

tures more or less distinctive of the cultures I hold to be conspecific with Berlese's hyphomycete. Thus, Matruchot ascribes to the prolonged conidiophores of his variety a conspicuous irregularity with respect both to length of internodal portions and to the angles subtended at the nodes. To the nodes, moreover, he attributes a strong tendency toward lateral elongation whereby they sometimes acquire a somewhat branched or coralloid arbuscular form. The conidia he describes as having a length of 25 μ, a maximum width of 12 μ in the distal cell, and a greatest width of 8 μ in the proximal cell. In several of the 9 conidia figured by him the inequality between the upper and the lower segment is not pronounced either with respect to width or with respect to size.

As the several peculiarities which Matruchot detected in material developing on rotten wood persisted during artificial cultivation on different substrata, he held them, not unjustifiably, to represent constant characteristics. In view, however, of what he considered extreme polymorphism in the fungi here concerned, he deemed it inadvisable to propose a separate species. Accordingly he subsumed his fungus under *Arthrobotrys superba* as a new variety, whereby it yet was given equal rank with *A. oligospora*, which likewise he recognized as a variety of Corda's species. It can only be presumed that apart from the variety *irregularis* all the *Arthrobotrys* material studied by Matruchot was referable to *A. oligospora*. In discussing briefly the "forme polyspore," which he observed on dry horse dung and which he held to be typical *A. superba*, he makes no mention of any distinctiveness attaching to the conidia. Most probably Matruchot, like other authors whose observations led them on the score of priority to apply Corda's binomial to *A. oligospora*, did not happen to encounter the much less frequent, less robust, but not less repeatedly capitate fungus that from the smaller dimensions and more nearly equal partitioning of its conidia corresponds much more closely to Corda's illustrated account, and therefore is better deserving of being identified with Corda's species.

It remains uncertain how much significance can properly be ascribed to the wide difference in the statements relating to length of conidiophorous filaments given respectively by Berlese and

Matruchot. In the diagnosis of *Cephalosporium roseum* var. *arthrobotryoides* a range of 150 to 200 μ is given for this dimension, whereas the erect branches of *Arthrobotrys superba* var. *irregularis* are stated to attain readily a length of several millimeters. Berlese's material may have developed on the natural substratum under conditions favoring cessation of growth in the individual conidiophore after development of a single conidial head—under conditions comparable, for example, to those operative in nematode-infested agar plate cultures, where as a rule *A. superba*, *A. oligospora*, and *A. conoides*, despite their strong tendency toward production of successive conidial clusters on a greatly prolonged uniaxial filament, are found in a monocephalous state almost as constantly as the purely monocephalous congeneric species I described under the binomial *A. musiformis* (**4**, p. 477–482). Yet Berlese's statement on length of fertile hyphae is not lacking in taxonomic import; for in my cultures of the fungus under discussion, the conidiophores, regardless of their ultimate length, often form their first conidial clusters at heights less than 200 μ, while, by way of contrast, conidiophores of *A. oligospora* only rarely produce the first conidial cluster less than 300 μ from the base.

The rather satisfactory agreement of my fungus with Berlese's description can be turned to account for nomenclatorial purposes all the more readily because Lindau (**9**, p. 371) in 1905 raised Berlese's variety to specific rank within the genus *Arthrobotrys* as *A. arthrobotryoides* (Berl.). The somewhat abridged German diagnosis given under the new binomial includes nearly all important details of the original account, though its failure to mention anything about the upper cell of the conidium being only slightly more distended than the lower cell appears unfortunate. However, in accordance with the type method of nomenclature, now firmly established, the omitted detail would seem to apply to the species no less than it applied to the variety; there being no question here of an intended factual correction as the transfer was made apparently without any first-hand examination of relevant material. Nor, apparently, has any usage intervened to modify the original characterization. Accordingly, in the absence of

serious adverse considerations, I am referring my fungus to *A. arthrobotryoides*.

Lindau expressed some uncertainty whether the species he renamed might not belong to *Arthrobotrys superba;* the latter being interpreted by him, as by Matruchot, to include *A. oligospora* as a somewhat depauperate variety. The fungus under discussion assuredly is separate from the congeneric form I hold referable to Corda's species; its separateness being manifest in parallel cultures despite the intimate interrelationship between all typical species of *Arthrobotrys*.

In old maizemeal-agar plate cultures the fungus occasionally gives rise to multicellular resting bodies through gradual distension and induration of uniaxial (FIG. 4, *A*) or branched (FIG. 4, *B*) portions of submerged hyphae. These resting bodies, like the similar structures of *Dactylella heterospora* and *Arthrobotrys cladodes* var. *macroides*, reveal pronouncedly globuliferous contents within walls that in many instances are thickened somewhat less markedly than the walls surrounding the more deeply colored chlamydospores produced in cultures of *A. oligospora*, *A. conoides*, *A. musiformis*, and *Dactylaria thaumasia*.

A RETIARY FUNGUS WITH UNUSUALLY LARGE PLURISEPTATE CONIDIA

A maizemeal-agar plate culture which after being permeated with *Pythium* mycelium had been further planted with a pinch of decaying material from old potato vines collected near Presque Isle, Me., on Oct. 2, 1941, showed, on examination 10 days later, development of a nematode-capturing fungus that presented some features in an unfamiliar combination. On its tall, sparsely scattered conidiophores were borne, for the most part singly, swollen ellipsoidal conidia, which, if predominantly triseptate, nevertheless very often contained 4 cross-walls (FIG. 4, *C*). The reproductive apparatus thus offered obvious parallelism with *Dactylella gephyropaga* Drechsl. (**4**, p. 508–513), except that the conidia here were of conspicuously greater length, often measuring more than 60 μ in this dimension. Further, the adhesive networks operative in capture of eelworms showed no scalariform development, but consisted throughout of arcuate or bail-like

elements, and hence greatly resembled the retiary apparatus displayed, among pluriseptate species, by *Dactylaria thaumasia* and *Dactylaria polycephala* Drechsl. (**4**, p. 527–531). As both of these species are sometimes difficult to identify with complete certainty in nematode-infested cultures, the fungus of ambiguous morphology was isolated by transferring aseptically some of the large conidia from their supporting hyphae to sterile maizemeal-agar plates.

The conidia germinated promptly, their germ tubes soon growing out into a compact branching mycelium, with numerous hyphal anastomoses and with all septa guarded by Woronin bodies. In the pure culture thus obtained the mycelium has never been found giving rise to predaceous organs. For a time no success was achieved in inducing development of predaceous apparatus by transferring sizable slabs of agar newly permeated with hyphae to Petri-plate cultures abundantly infested with active nematodes. The reason for this unexpected failure became clear when the temperature of the laboratory, ordinarily kept at about 25° C., went down to 17° C. for a period of several days. Under the cooler conditions hyphal bails and networks promptly came into being everywhere in the transferred slabs, and then were formed more gradually at intervals along the straightforward hyphae pushed out sparsely into the subjacent medium. Similarly luxuriant production of bails and networks took place whenever cultures containing the fungus in association with eelworms were kept at the lower temperature; many of the reticula becoming 5 or 6 times more extensive than the examples shown in figure 5, *A*, *a–c*. Contrary to expectations suggested by the robust dimensions of the conidia from which the pure culture was started, the networks have for the most part been rather more delicate than those of any other retiary species except *Dactylaria polycephala*. In their manner of operation they have shown no special distinctiveness. Eelworms measuring from 150 to 600 μ in length are held fast, partly by adhesion and partly by enmeshment. The integument of each eelworm is narrowly penetrated in one or more places; penetration being accomplished in each instance by a fine outgrowth that sometimes is extended from a thick stumpy branch thrust firmly against the animal

after its capture (FIG. 5, *B*), but at other times is extended from the inner side of an enveloping loop or from an adhesive hyphal element merely in close contact with the animal (FIG. 5, *C*). Wherever the integument has been perforated a globose enlargement is intruded, severing the animal internally and thus disabling it. Each globose enlargement soon gives off a few assimilative hyphae, which push their way lengthwise through musculature and organs, everywhere bringing about globulose degeneration. After the hyphae have completely taken up the globulose materials, their protoplasm is withdrawn backward into the external mycelium.

The relatively low temperatures between 15° and 20° C. not only permit a lively display of predaceous activity, but also are far more favorable than temperatures near 25° C. for development by the fungus of asexual reproductive apparatus. Under the cooler conditions the fungus promptly gives rise to numerous erect conidiophores, most of which soon come to support 2 (FIG. 5, *D*), 3 (FIG. 5, *E*) or 4 (FIG. 5, *F*) elongate ellipsoidal conidia. In large part the arrangement of plural conidia indicates successive development. Where, as is frequently the case, a spore is attached laterally at a slight geniculation a short distance below the apex bearing the terminal spore (FIG. 5, *D*, *a*, *b*; *E*, *b*, *c*), it may be presumed that the laterally sessile spore was formed originally at the tip of the supporting hypha, and was later pushed aside as the hypha resumed growth to produce another spore on its newly extended tip. Through repetition of this process 2 spores (FIG. 5, *F*, *b*, *c*) often come to be attached at successive geniculations below the apex bearing the terminal spore (FIG. 5, *F*, *d*); a strictly acropetal sequence of development being manifest in such instances. Frequently, in addition, a conidiophore may produce a conidium on the tip of a short spur-like branch (FIG. 5, *E*, *a*; *F*, *a*) arising usually from a position somewhat below that of the original axial tip; and, indeed, sometimes two lateral spurs are present, each bearing a conidium. Production of spores on such branches would seem more or less indeterminate with respect to time, except that it probably never precedes development of the first conidium on the main hyphal axis.

The conidia thus produced are the largest formed by any of the hyphomycetes so far known to subsist through capture of nematodes. Spores developed plentifully in maizemeal-agar plate cultures at temperatures near 17° C. were used for the measurements underlying the data on conidial dimensions supplied in the diagnosis. The 100 specimens selected at random gave values for length, expressed as the nearest integral number of microns, with a distribution as follows: 46 μ, 1; 49 μ, 1; 53 μ, 1; 54 μ, 1; 55 μ, 2; 56 μ, 5; 57 μ, 2; 58 μ, 3; 59 μ, 2; 60 μ, 9; 61 μ, 13; 62 μ, 4; 63 μ, 12; 64 μ, 12; 65 μ, 12; 66 μ, 8; 67 μ, 2; 68 μ, 3; 69 μ, 4; 70 μ, 1; 71 μ, 2; and values for width distributed thus: 21 μ, 3; 22 μ, 7; 23 μ, 12; 24 μ, 20; 25 μ, 21; 26 μ, 19; 27 μ, 14; 28 μ, 2; 29 μ, 2. Of the 100 conidia 50 showed the triseptate partitioning usual in *Dactylella bembicodes* Drechsl. (**4**, p. 487–492), each consisting of a small basal cell, a small antepenultimate cell, a large penultimate cell, and a small apical cell (FIG. 5, *D, a; E, c; F, b, d; G–K*); the lengths of the 4 cells averaging, respectively, 8.2 μ, 8.5 μ, 37.6 μ, and 8.8 μ. Thirty-five of the 100 conidia showed the quadriseptate partitioning frequent in *D. ellipsospora* Grove (**8**; **4**, p. 492–496), each consisting of a small basal cell, a small parabasal cell, a large median cell, a small penultimate cell, and a small apical cell (FIG. 5, *E, a, b; F, a, c; L–P*); the lengths of the 5 cells here averaging, respectively, 7.8 μ, 7.7 μ, 36.7 μ, 6.6 μ, and 4.2 μ. The remaining 15 conidia showed several types of partitioning: six were biseptate after the manner familiar in *D. heterospora*, each consisting of a small basal cell, a large median cell, and a small apical cell (FIG. 5, *Q*); one, though also biseptate, was divided into a small basal cell, a small penultimate cell, and a large distal cell (FIG. 5, *R*); three were composed individually of a small basal cell, a small parabasal cell, a small antepenultimate cell, a large penultimate cell, and a small apical cell (FIG. 5, *S, T*); four consisted individually of a small basal cell, a large antepenultimate cell, a small penultimate cell, and a small apical cell (FIG. 5, *U*); a single specimen with 5 cross-walls had its two large median cells intercalated between two smaller proximal cells and two smaller distal cells (FIG. 5, *V*).

Sporulation is less prompt and less abundant when the fungus is grown in maizemeal-agar plate cultures at the relatively high

temperatures—mostly between 28° and 32° C.—prevailing indoors near Beltsville, Md., during the summer. Further, the conidia then produced are, in general, of smaller dimensions. This difference in size, appreciable even in the specimens that with regard to shape and septation (FIG. 4, *D*, *a–d; f–i*) show little divergence from those formed under cooler conditions, is especially marked in the frequently very numerous examples that clearly betray thwarted development in obovoid shape and meager partitioning by 1 or 2 proximal cross-walls (FIG. 4, *D*, *e*, *j–l*). A large proportion of the conidia germinate while still attached to their supporting hyphae by extending a germ tube from the distal end (FIG. 4, *E*). Where germination occurs after the spore has fallen off, the germ tube is more usually sent up from a position closer to the basal end (FIG. 4, *F*).

As the fungus never shows scalariform development but always forms its predaceous networks by adding one bail-like loop after another, it must be held to differ decisively from *Dactylella gephyropaga* in its vegetative stage. The composition and texture of its predaceous networks offer strong similarities with *Dactylaria polycephala*, which, however, is very adequately distinguished by conidial apparatus wherein pluriseptate conidia are frequently arranged in a succession of distinctly capitate clusters. As the 3 or 4 conidia commonly produced by conidiophores of the present fungus at suitably low temperatures are attached in positions often 5 to 25 μ apart, they offer a more or less capitate appearance mainly by virtue of their large dimensions. The difficulty of recognizing such loose arrangement as capitate clustering for diagnostic purposes is aggravated through the circumstance that with meager nourishment the conidiophores often bear only a single conidium or, perchance, two conidia, and then reveal a sporulating habit much like that of *D. gephyropaga* or of *Dactylella bembicodes*. Nevertheless, since its more luxuriant sporulation is apparently more expressive of good development than is its meager sporulation, the fungus would seem somewhat better referable to the capitate genus *Dactylaria* than to *Dactylella*. Assignment to the capitate genus, moreover, conveniently brings the fungus into the same fold with *Dactylaria thaumasia*, to which, from resemblances in character of preda-

ceous networks as well as from similarities in shape and arrangement of conidia, it seems most closely related. When grown in parallel cultures with *D. thaumasia* its separateness from that species is sufficiently evidenced in the larger dimensions of its conidia, in the production of these conidia in lesser numbers on the individual conidiophores, and in complete absence of chlamydospores.

Among the various hyphomycetes which have been made known without reference to any predaceous relationship, yet which from similarities of their conidial apparatus may be presumed to subsist by capture of nematodes, are two species with large swollen conidia that in respect to dimensions approach, even if they do not equal, the aerial spores produced in pure cultures of the present fungus under congenially cool conditions. One of these species, *Monacrosporium elegans* Oudemans (11), found on rabbit dung in The Netherlands, was set forth as giving rise to solitary, triseptate, mostly pyriform conidia, 50 to 60 μ long and 16 to 21 μ wide, on conidiophores about 250 μ high, 4 to 6 μ wide at the base and 2 to 3 μ wide at the tip. As the solitary condition of the conidium was affirmed not only in Oudemans' diagnosis of the species (Hyphae conidiophorae . . . singulae conidium solitarium gerentes . . .) but also in his definition of the genus *Monacrosporium* he erected at the time (Hyphae conidiophorae . . . apice unicum tantum conidium . . . gerentes) it may be inferred that in his material the tendency toward production of plural conidia, if present at all, was much feebler than in my cultures. The second of the two large-spored species here in question was found on a partly decayed male inflorescence of the oil palm, *Elaeis guineensis* Jacq., in Sumatra. It was presented by Boedijn as a new member of Oudemans' genus under the binomial *M. megasporum*, though its erect, unbranched, septate conidiophores, 300 to 500 μ long and 5.5 to 7.5 μ wide, were described as having at the tip several warty protuberances, each functional in serving as support of a separate conidium. Boedijn's figure shows several of the sterigmatic warts closely aggregated on the somewhat expanded apex of each conidiophore —an arrangement certainly much closer than that prevailing in my fungus. The conidia of *M. megasporum*, described in part

as being elliptical, as containing usually 3 septa, and as measuring 35 to 57.5 μ in length by 15.5 to 27.5 μ in width, would seem from the several examples illustrated, to taper less markedly toward base and apex than the conidia produced in my cultures, besides differing in being drawn out abruptly at the proximal end into a minute hilar protrusion.

Aside from comparison of reproductive structures, determination of predaceous hyphomycetes, and especially of hyphomycetes subsisting by capture of eelworms, necessarily entails consideration of agreement or disagreement with respect to predaceous apparatus. Unfortunately the literature pertaining to the group of fungi here concerned was written, for the most part, without any suspicion of predaceous relationships, so that treatment of the vegetative stage usually affords scope for comparison only with respect to the commonplace features of undifferentiated mycelium. In some instances, it is true, a fungus found capturing and consuming nematodes may be satisfactorily assigned to an established species even where no information is given as to the existence or character of predaceous organs in the material on which the species was based. Thus, since the several typical representatives of the genus *Arthrobotrys* which have been appropriately studied in living cultures—*A. dactyloides* Drechsl. (**4**, p. 482–487) must be held aberrant because of its production, now and then, of swollen biseptate conidia—have all been found capturing nematodes by means of adhesive networks composed of bail-like hyphal loops,[2] there is good reason to presume that similar biological adaptation and similar predaceous apparatus belonged likewise to the similar fungi described as species by

[2] Very recently, however, an undeniable exception to the general rule has come to light in a predaceous hyphomycete specially adapted to capture minute Sminthurid springtails; the insects being held through adhesion to ovoid glandular cells borne aloft individually on short unicellular erect columnar stalks arising from different segments of a prostrate anastomosing hyphal network. Although the concomitant conidia, mostly about 22 μ long and 5 μ wide, are borne on longish sterigmatic spurs and thus appear in looser capitate arrangement than is prevalent in the better known congeneric nematode-capturing species, their consistently uniseptate condition, together with their production in well defined clusters that are formed terminally one after another on a slender conidiophore given to repeated uniaxial elongation, makes the fungus unreservedly eligible for inclusion in *Arthrobotrys*.

earlier observers. Consequently the determination of two retiary nematode-capturing fungi as *A. superba* and *A. arthrobotryoides* need arouse no serious misgiving with regard to correspondence in the vegetative stage, however silent the relevant descriptions by Corda and Berlese may be in respect to predaceous features. Lack of positive knowledge on adaptations for holding prey is, however, very serious where, as in the case of the fungus from Maine, comparison must be made with descriptions of broad-spored species of *Dactylella* (including *Monacrosporium*) and *Dactylaria*. For among such species are utilized all types of specialized apparatus known to be operative in capture of nematodes—constricting rings, adhesive networks compounded of bail-like hyphal loops, scalariform adhesive networks, adhesive knob-like cells on sturdy stalks, and smaller adhesive cells on frail stalks together with non-constricting rings; so that here the conidiophores and conidia, in themselves, give little indication as to which type of predaceous apparatus might be associated with them. Hence, even if the fungus from Maine agreed well in its reproductive structures to the description of *M. elegans* or of *M. megasporum*, a strong possibility of outright disagreement in the vegetative stage would nevertheless remain.

The fungus, therefore, is described as a new species. A specific term compounded of words meaning, respectively, "cold" and "to love" may serve conveniently to direct attention to its thermal preference.

Dactylaria psychrophila sp. nov.

Mycelium effusum; hyphis sterilibus hyalinis, septatis, plerumque 2–6 μ crassis, laqueos tenaces arcuatos vel circulares in reticula saepe conjunctos proferentibus; his laqueis reticulisque vermiculos nematodeos illaqueantibus, deinde tum integumentum animalis captivi perforantibus, tuber debilitans vel mortiferum intrudentibus, hyphas intus evolventibus quae carnem exhauriunt. Hyphae fertiles incoloratae, septatae, erectae, plerumque 150–500 μ altae, basi 5–9 μ crassae, apice 2.5–4.5 μ crassae, modo simplices modo subter apicem uno ramulo usque 35 μ longo (quandoque duobus ramulis ejusmodi) instructae, primum 1 vel 2 conidia gignentes, mox semel vel bis recrescentes et 1 vel 2 alia conidia deinceps gerentes, itaque postea 3 vel 4 conidia in capitulum laxum saepe ferentes. Conidia hyalina, ellipsoidea vel fusoideo-ellipsoidea, sursum rotundata, deorsum truncata, 1–5 septata vulgo triseptata vel quadriseptata, plerumque 46–71 μ (saepius circa 62.3 μ) longa, 21–29 μ (saepius circa 24.7 μ) crassa.

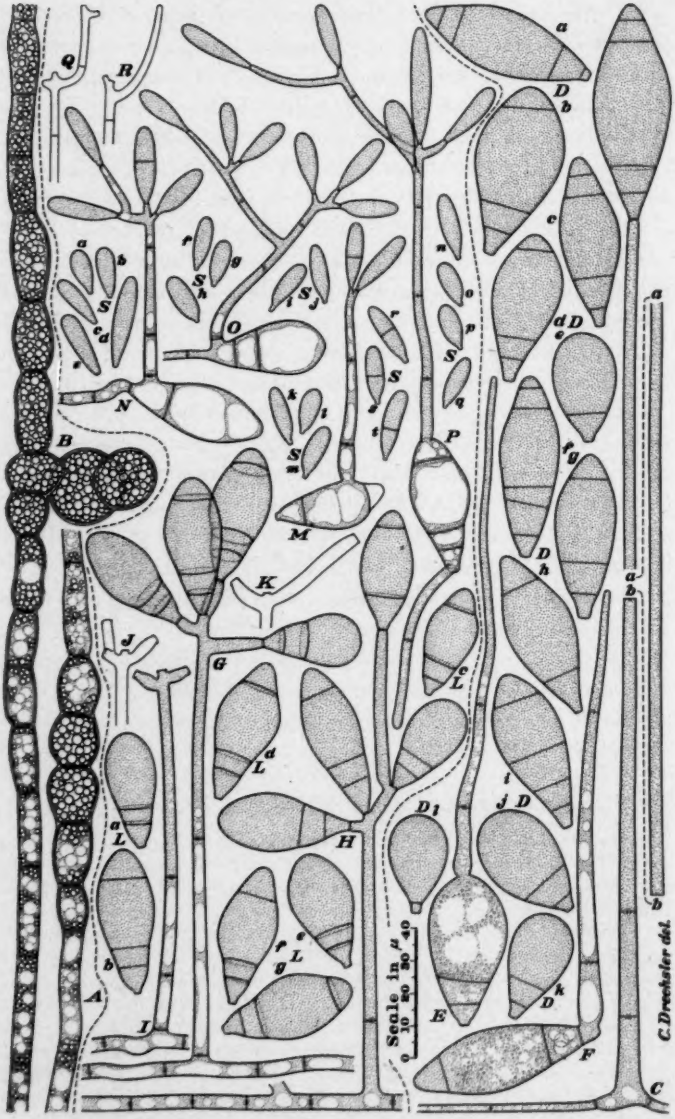

FIG. 4. *A, B, Arthrobotrys arthrobotryoides; C–F, Dactylaria psychrophila* (typical strain); *G–S, Dactylaria psychrophila* (aberrant strain).

Mycelium spreading; vegetative hyphae hyaline, septate, mostly 2 to 6 μ wide, often, especially in the presence of nematodes, giving rise to hyphal bails and loops which though at first discrete are later usually compounded into more or less extensive networks; the bails and networks capturing nematodes through adhesion and entanglement, perforating the integument of each animal and intruding one or more mortiferous excrescences from which are extended assimilative hyphae to appropriate the fleshy contents. Conidiophores hyaline, erect, septate, mostly 150 to 500 μ high, 5 to 9 μ wide at the base, 2.5 to 4.5 μ wide at the tip, sometimes simple and sometimes bearing near the tip a branch (occasionally 2 branches) up to 35 μ long, often on giving rise terminally to 1 or 2 conidia elongating once or twice to produce 1 or 2 additional conidia, and thus frequently coming to bear 3 or 4 conidia in a loose head. Conidia hyaline, ellipsoidal or fusoid-ellipsoidal, rounded at the distal end, somewhat truncate at the proximal end, when developed under favorable conditions measuring mostly 46 to 71 μ (average 62.3 μ) in length and 21 to 29 μ (average 24.7 μ) in greatest width, containing from 1 to 5 cross-walls but mostly divided by 3 or 4 cross-walls into 4 or 5 cells whereof one, as a rule—the penultimate cell usually in triseptate specimens and the median cell usually in quadriseptate specimens—greatly exceeds the others in size.

Capturing and consuming eelworms that measure usually 150 to 600 μ in length and that belong to species of *Acrobeloides*, *Cephalobus*, *Plectus*, *Rhabditis*, and other genera, it occurs on decaying leaves and stems of *Solanum tuberosum* L. near Presque Isle, Maine.

A SECONDARY CONIDIAL STAGE APPARENTLY REFERABLE TO DACTYLARIA PSYCHROPHILA

Although the foregoing account of *Dactylaria psychrophila* is based primarily on study of a single culture, it applies equally well to more than a dozen other cultures, similar in behavior and morphology, that were derived from other specimens of decaying potato vines also collected near Presque Isle, Me., on Oct. 2, 1941. Mention must be made, however, of differences noted in an aberrant culture isolated from the same general collection of old potato vines. Under congenially cool conditions and on suitable substrata, the strain in question shows very satisfactory agreement with the other strains; but when unfavorably high

temperatures supervene it responds by even more pronounced shortening of the conidiophores, which, as a result, then often bear their first conidia at heights between 80 and 130 μ (FIG. 4, *G, H, I*). Plural production of conidia in loose heads (FIG. 4, *G, H*), following subapical branching or prolongation of the supporting hyphae (FIG. 4, *I–K*), continues with little abatement, but rather generally the conidia then formed measure only 30 to 50 μ in length and 15 to 20 μ in greatest width (FIG. 4, *L, a–g*). Premature germination, while the conidia are still attached, occurs only rarely. In aging maizemeal-agar plate cultures, especially in cultures where species of *Penicillium* have partly overgrown the substratum, a fallen conidium often puts forth an erect or ascending germ-conidiophore, which may be simple (FIG. 4, *M*), or somewhat branched (FIG. 4, *N, O*), or successively prolonged (FIG. 4, *P*). On these germ-conidiophores are frequently borne 4, 5, or 6 secondary conidia, mostly elongate ellipsoidal or elongate obovoid in shape, and often drawn out noticeably at the basal end. Varying in length from 14 to 35 μ, and in width from 4.8 to 7.5 μ, the secondary conidia are much smaller than the primary spores that produce them. While most of them evidently remain continuous (FIG. 4, *S, a–q*), some become divided by a median septum (FIG. 4, *S, r–t*).

Conidial apparatus closely resembling the subsidiary reproductive stage just described came to light in a maizemeal-agar plate culture planted with leaf mold taken from deciduous woods near Presque Isle, Me., on Oct. 2, 1941. A tract about 25 square millimeters in extent adjoining the deposit of forest refuse afforded development of a sparse mycelium consisting of colorless septate filaments mostly 2.5 to 3 μ in width. From these filaments, not any of which were supplied with predaceous organs, arose hyaline, meagerly septate, tapering, erect hyphae, mostly 50 to 90 μ high, 4 to 5 μ wide at the base and 1.5 to 2.5 μ wide near the tip, where they gave off usually 1 to 3 lateral spurs (FIG. 3, *C–E; F, a, b; G, a, b*). As the axial tip and each of the spurs supported a conidium, most of the erect hyphae bore aloft 2, 3, or 4 conidia in loose capitate arrangement. These conidia were of elongate ellipsoidal or elongate obovoid shape, and usually tapered noticeably toward the blunt narrow basal end. They measured from

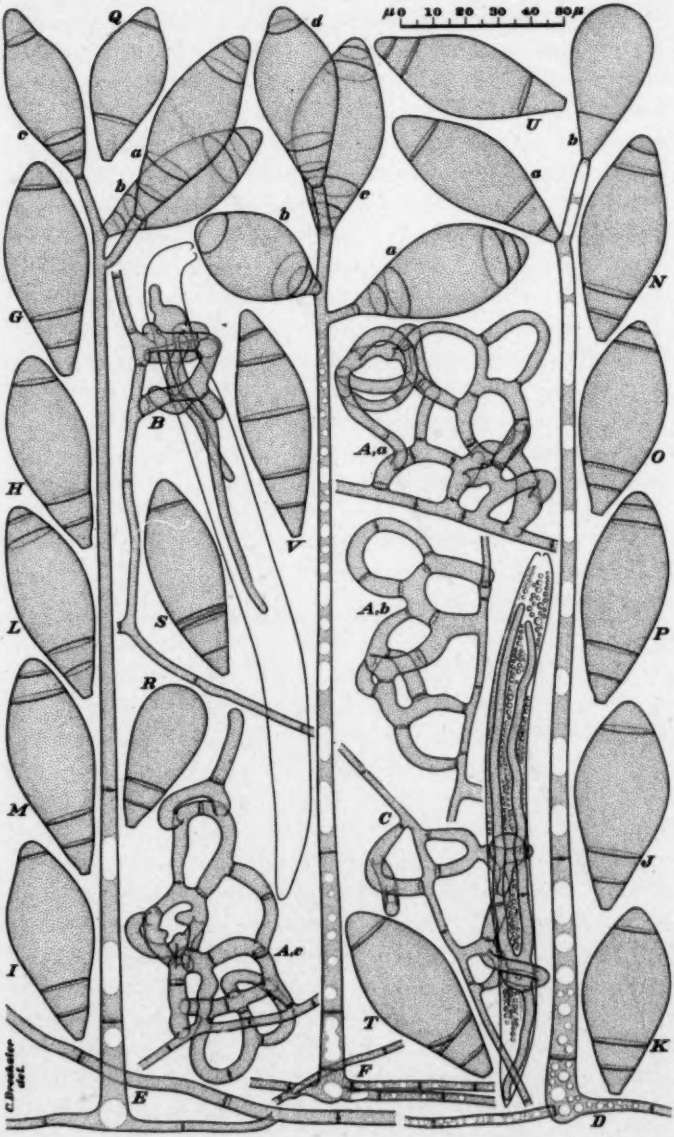

FIG. 5. *Dactylaria psychrophila* (typical strain).

16 to 27 μ in length and from 5.4 to 7.2 μ in greatest width. Though they were predominantly unseptate in their definitive state (FIG. 3, *H*, *a–z*; *I*, *a–j*), some of them became partitioned by a median cross-wall (FIG. 3, *K*, *k–q*).

Owing in part to the low stature of the sporiferous hyphae and their tendency to collapse rather quickly on exposure to normal evaporation, efforts to isolate the fungus by aseptic removal of conidia proved unsuccessful. Consequently it remains uncertain whether the modest conidial apparatus represented the principal reproductive stage of a small hyphomycete, or an accessory stage of some relatively large mucedinaceous form. That it may belong to *Dactylaria psychrophila* is suggested by its occurrence in decaying vegetable material collected in the same locality at the same time, and by the resemblance of its conidia to the secondary conidia formed occasionally in the aberrant strain of the very robust nematode-capturing hyphomycete.

A KNOBBED NEMATODE-CAPTURING HYPHOMYCETE WITH A TRICHOTHECIUM STAGE

A similarly perplexing fungus appeared in a maizemeal-agar plate culture which after being permeated with *Pythium* mycelium had been further planted with leaf mold collected in deciduous woods near Fairfax, Va., on Nov. 10, 1942. Its straightforward, sparingly branched, colorless, vegetative hyphae, septate at intervals of 15 to 35 μ, and measuring 2 to 2.4 μ in width, bore globose cells, mostly 5.8 to 7.2 μ in diameter, on stalks 1.5 to 5 μ long and 2 to 2.5 μ wide (FIG. 3, *J*, *a–e*). The resemblance of these globose cells to the adhesive predaceous organs of *Dactylella ellipsospora* and of the two allied species I have described as *Dactylella asthenopaga* (**4**, p. 496–499) and *Dactylaria haptospora* (**5**, p. 456–461) identified them unmistakably as organs for capture of nematodes, though, owing very probably to scarcity of suitable prey, nematodes were not actually seen captured by them. Apart from the predaceous structures formed on the surface of the substratum as well as in submerged positions, the mycelial filaments were found bearing a sparse array of colorless, sparingly septate, erect, tapering conidio-

phores often 35 to 65 μ high, 2 to 3.5 μ wide at the base, and 1 to 1.5 μ wide at the tip. In many instances these conidiophores showed no branching, though rather often, after they had produced a single spore at the tip and had fallen over on the substratum, they would give rise from one of their basal cells to a new conidiophore. Now and then, however, a conidiophore (FIG. 3, *J, f*) would give off one or even two fertile branches (FIG. 3, *J, g, h*) while still in an erect posture. The conidia were generally of elongate ellipsoidal shape, with the distal end bluntly rounded and the basal end perceptibly truncate (FIG. 3, *K, a–h*). They measured mostly 17 to 27 μ in length by 4.2 to 5.6 μ in greatest width, and were consistently divided by a single cross-wall at the middle or slightly above the middle.

As all efforts to isolate the fungus by aseptic removal of bacterium-free conidia proved unsuccessful, it has not been possible to determine whether the reproductive apparatus found associated with the knob-bearing mycelium is to be considered a primary sporulating stage or a subsidiary stage. *Dactylella ellipsospora*, the most frequent of the 3 species known to form predaceous organisms of the type here in question, had developed abundantly in the same culture, though no hyphal connection with it could be discovered. The globose cells appeared, in general, somewhat smaller than those characteristic of *D. ellipsospora;* so that with respect to size they more closely resembled the predaceous organs of *Dactylella asthenopaga* and *Dactylaria haptospora*. The latter two species, however, were not observed in the same culture with the fungus under discussion, nor, for that matter, in any of the several dozen other cultures planted with material from the same collection of leaf mold. Nothing that could be taken for a subsidiary sporulating stage has ever been noted in my pure cultures of *D. ellipsospora, D. asthenopaga,* and *D. haptospora*.

If the conidial apparatus under discussion should represent a primary sporulating stage, as seems not unlikely, the fungus would be properly referable to *Trichothecium*. In this genus it would offer close similarity to *T. arrhenopum*, a delicate species I have recently described (7) as a destructive parasite on oospores

of *Pythium graminicolum* Subr. With respect to natural relationship it appears far removed from the widely familiar *T. roseum* Link.

DIVISION OF FRUIT AND VEGETABLE CROPS AND DISEASES,
BUREAU OF PLANT INDUSTRY STATION,
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EXPLANATION OF FIGURES

FIG. 1. *Arthrobotrys cladodes* var. *macroides;* drawn with the aid of a camera lucida to a uniform magnification; ×500 throughout. *A*, *B*, Portions of mycelial filament, on each of which a predaceous network has been produced. *C*, Portion of mycelium with a predaceous network that has been operative in capturing a nematode referable to *Acrobeloides* sp.; from the 3 bulbous enlargements intruded into the animal to disable it assimilative hyphae have grown lengthwise through the fleshy interior. *D*, Portion of prostrate hypha with 2 conidiophores, one of which, *a*, is shown with its cluster of conidia attached, while the other, *b*, a distally branched specimen whereon 2 clusters had been borne, is shown in a denuded state. *E*, Portion of prostrate hypha that has given rise to 3 conidiophores; the conidiophore *a*, bearing a subapical branch, is shown with its 2 clusters of conidia attached, while the simple conidiophores, *b* and *c*, are shown denuded of their spores. *F*, Portion of prostrate hypha bearing an unusually short conidiophore.

G, Portion of prostrate hypha with a denuded conidiophore bearing a subapical branch rather markedly expanded at its tip. *H*, Denuded terminal portions of conidiophores, *a–e*, showing arrangement of the denticulations on which the conidia were borne. *I*, *J*, Assortment of conidia, *a–z*, showing variations in shape, in size, and in position of the cross-wall. *K*, Conidia, *a–d*, germinating by emission of a basal germ tube. *L*, Three pairs of conidia, *a–c*, united by vegetative anastomoses. *M*, Conidium anastomosed with a mycelial filament. *O*, Vegetative hypha, with small vacuoles beginning to form within cellular contents otherwise nearly homogeneous in appearance. *P*, Strongly vacuolate enlarged hypha with some accumulation of small globules. *Q*, Branched portion of mycelial hypha with more pronounced accumulation of small globules. *R*, Resting body consisting of 11 cylindrical cells and 1 strongly inflated cell. *S*, *T*, *U*, Resting bodies with their component cells more or less strongly inflated and filled with relatively large globules.

FIG. 2. *Arthrobotrys arthrobotryoides;* drawn with the aid of a camera lucida to a uniform magnification; ×500 throughout. *A*, Portion of mycelial hypha on which a small predaceous network has been formed. *B*, Portion of mycelial hypha that has produced a somewhat extensive network, *a*, as well as a smaller network, *b*, compounded of only 4 bail-like elements. *C*, Portion of mycelial filament with a small predaceous network that has been operative in capturing a nematode referable to *Acrobeloides* sp.; the mortiferous enlargement from which 3 assimilative hyphae have grown through the fleshy interior was intruded directly from the inner aspect of an enveloping bail-like element, the narrow communication through the perforated integument being shown in profile. *D*, Portion of mycelial filament with a small predaceous network that has been operative in capturing a nematode belonging to *Acrobeloides* sp.; the 2 mortiferous enlargements whereby the animal was disabled were intruded from 2 short branches which manifestly grew firmly against the animal after its capture; only the larger of the mortiferous bodies—the one from which 2 assimilative hyphae were extended toward the tail end—is shown connected in profile view with the external branch from which it originated. *E*, Conidiophore with 10 conidia borne in the typically monocephalous arrangement usual in nematode-infested cultures. *F*, Denuded conidiophore from a nematode-infested culture; for lack of space it is shown in 3 portions separated at the cross-walls *a* and *b*. *G*, Portion of a fasciated mycelial strand formed aerially in pure culture under humid conditions; from the component hypha shown uppermost are given off 2 conidiophores; one of the conidiophores, *a*, bears 20 conidia in 4 clusters so indistinctly separated as to present the appearance of botryose arrangement; the other conidiophore, *b*, shows in its denuded state similarly indistinct separation of its 4 denticulate nodes. *H*, *I*, *J*, Denuded conidiophores from a pure culture, showing arrangement of denticulations on the prolonged axis. *K*, *L*, Somewhat branched distal portions of denuded conidiophores that developed in a pure culture on maizemeal agar under humid conditions. *M*, Random assortment of conidia, *a–q*, from a nematode-infested culture kept at about 20° C., showing normal variation in size, in shape, and in position of cross-wall. *N*, Assortment of conidia, *a–p*, developed in pure culture under humid conditions at a temperature of about 20° C.; some of the spores (*c*, *g*, *n*) illustrate rather extreme variations in shape, in size, or in position of septum.

FIG. 3. Drawn with the aid of a camera lucida to a uniform magnification; ×500 throughout.

A, B, Arthrobotrys arthrobotryoides: A, Assortment of uniseptate conidia, *a–z*, formed in pure culture on maizemeal agar at temperatures varying mostly between 28° and 32° C. *B*, Assortment of unseptate conidia, *a–j*, formed likewise at temperatures between 28° and 32° C.

C–I, Sporulating stage possibly belonging to *Dactylaria psychrophila: C, D, E*, Portions of prostrate hyphae, each with a conidiophore; on the conidiophores are borne, respectively, 2, 3, and 4 conidia. *F*, Portion of a prostrate hypha from which has arisen a young conidiophore, *a*, bearing only a single conidium, and a slightly older conidiophore, *b*, bearing 2 conidia. *G*, Portion of a prostrate hypha with a rather young conidiophore, *a*, bearing 2 spores, and a somewhat older conidiophore, *b*, bearing 3 spores. *H*, Unseptate conidia, *a–z*, showing variations in size and shape. *I*, Assortment of conidia including some continuous specimens, *a–j*, and some uniseptate specimens, *k–q*.

J, K, Predaceous knob-bearing fungus with delicate *Trichothecium* stage: *J*, Portion of mycelial filament bearing 5 predaceous knob-like organs, *a–e*, and a conidiophore, *f*, with 2 branches, *g* and *h*. *K*, Assortment of conidia, *a–h*, showing normal variations in size, in shape, and in position of cross-wall.

FIG. 4. Drawn with the aid of a camera lucida to a uniform magnification; ×500 throughout.

A, B, Arthrobotrys arthrobotryoides: A, Somewhat immature resting body from a maizemeal-agar plate culture 3 months old. *B*, More nearly mature resting body from same culture.

C–F, Dactylaria psychrophila (typical strain): *C*, Conidiophore bearing only a single conidium, as found frequently in nematode-infested cultures. *D*, Assortment of conidia, *a–l*, formed in a maizemeal-agar plate culture kept at temperatures between 28° and 32° C. *E*, Conidium with an apical germ tube, as often found while still attached to the conidiophore in cultures kept at 28° to 32° C. *F*, Conidium germinating after falling on moist substratum.

G–S, Dactylaria psychrophila (aberrant strain): *G, H*, Conidiophores, each bearing 4 conidia, from a pure culture on maizemeal agar grown at temperatures between 28° and 32° C. *I*, Denuded conidiophore from same culture. *J, K*, Distal portions of denuded conidiophores likewise from same culture. *L*, Assortment of conidia, *a–g*, from same culture. *M–P*, Conidia which, after falling on the surface of a 40-day-old maizemeal-agar plate culture contaminated with *Penicillium* sp., have given rise to erect or ascending germ conidiophores whereon are borne a number of smaller secondary conidia. *Q, R*, Denuded distal portions of germ conidiophores. *S*, Random assortment of secondary conidia, showing normal variations in size and shape; with the more numerous continuous specimens, *a–q*, are included a few uniseptate specimens, *r–t*.

FIG. 5. *Dactylaria psychrophila* (typical strain) as found in cultures kept at temperatures near 17° C.; drawn with the aid of a camera lucida to a uniform magnification; ×500 throughout. *A*, Portions of hyphae, *a–c*, on each of which a predaceous network has been produced. *B*, Portion of mycelial filament with a predaceous network that has been operative in the capture of an eelworm referable to *Acrobeloides* sp.; 3 assimilative hyphae are being extended into the fleshy interior from the single mortiferous enlargement

intruded by one of the 2 short branches that grew firmly against the animal after its capture. *C*, Portion of mycelial hypha with a predaceous network that has been operative in the capture of an eelworm referable to *Acrobeloides* sp.; 2 mortiferous enlargements are visible within the integument, the one shown uppermost having been intruded from a hyphal branch curving only half-way around the animal, the other, nearer the tail, having been intruded from an enveloping loop; the second and older of the globose enlargements has given rise to 3 assimilative hyphae whose advance lengthwise through musculature and organs has resulted in globulose degeneration of the invaded parts. *D*, Conidiophore which after giving rise on its original apex to the conidium *a* resumed growth to produce a second conidium, *b*, on its new apex. *E*, Conidiophore with a short subapical spur on which the conidium *a* has been produced; on the original tip of its main axis it first gave rise to the conidium *b*, and then resumed growth to form the conidium *c* on a new apex. *F*, Conidiophore which, apart from producing the conidium *a* on a short subapical spur, has given rise on its axial hypha first to the conidium *b*, and then in succession, with repeated renewal of growth, to the conidia *c* and *d*. *G–P*, Representative assortment of conidia showing normal variations in size, in shape, and in partitioning with 3 or 4 cross-walls. *Q–V*, Conidia showing more unusual partitioning by cross-walls varying in number from 2 to 5.

NOTES ON OKLAHOMA CERCOSPORAE—III

W. Winfield Ray

Thirty-seven species of *Cercospora*, nine of which were described as new, have been recorded for Oklahoma since 1940.[1] Recent collections taken principally in 1942 have been sent for examination to Dr. C. D. Chupp, who discovered four new species among them.

At the request of Dr. Chupp, who very generously suggested the names and technical diagnosis, the following new species are herein described:

1. **Cercospora Gomphrenae** sp. nov.

Maculis orbicularibus, 0.5–4 mm. diam., alutaceis vel sordide cinereis, zona lata rubera vel purpurea restrictis; fungis amphigenis; stromatibus irregularibus, parvis, cellis paucis vel 35 μ longis, atro-fuligenis; fasciculis cum 4–20 conidiophoris divaricatis; conidiophoris in masse mediocriter nigris, singulatim dilute-fuligenis, apicibus pallidioribus et angustioribus, indistincte pluriseptatis, non-ramosis, rectis vel diverse curvatis, plerumque non-geniculatis, cicatricibus sporarum mediocribus ad apicibus subtruncatis, 4–5.5 × 30–150 μ, plerumque 50–90 μ; conidiis hyalinis, acicularibus, rectis vel leviter curvatis, indistincte pluriseptatis, ad bases truncatis, ad apices acutis, 2–3.5 × 30–135 μ.

Leaf spots circular, 0.5–4 mm. in diameter, tan to dingy gray, bordered by a wide red to purplish zone; fruiting amphigenous, stromata irregular, small, ranging from a few cells to 35 μ in length, dark fuligenous; fascicles 4 to 20 divergent stalks; conidiophores in mass fairly dark, singly pale fuligenous, tips paler and narrower, indistinctly multiseptate, not branched, straight to variously curved, mostly not geniculate, medium spore scar at the subtruncate tip, 4–5.5 × 30–150 μ, mostly 50–90 μ; conidia hyaline, acicular, straight to slightly curved, indistinctly multiseptate, bases truncate, tips acute, 2–3.5 × 30–135 μ.

Habit: On leaves of *Gomphrena globosa* L., Stillwater, Oklahoma, August 18, 1942. This species is distinct from other Cercosporae with acicular conidia on the Amarantaceae.

[1] Ray, W. Winfield. (Papers on Oklahoma *Cercosporae*.) Mycologia **32**: 271. 1940; **33**: 174–177. 1941; **34**: 558–562. 1942.

TYPE: In the herbarium of the Department of Plant Pathology, Cornell University, No. *33132*.

2. **Cercospora Gonolobi** sp. nov.

Maculis irregularibus, olivaceis vel cinereis vel atro-brunneis vel pustulis nigris, 2–14 mm. in spatio vel aliquando in areas magnas confluentibus, margine distincto egentibus; fungis amphigenis sed amplioribus in superiore superficie; stromatibus atro-brunneis, globosis, 20–40 μ vel raro tenus 75 μ; plerumque fasciculis densis, raro densissimis; conidiophoris pallidis vel mediocriter olivaceo-brunneis, apicibus pallidioribus et saepe leviter tumidis, cicatricibus sporarum parvis 1 vel 2, 1–6 septatis, parce ramosis, undulatis, 1–3 geniculatis, 3–4.5 × 10–80 μ; conidiis obclavatis vel cylindro-obclavatis, rectis vel paene, subhyalinis vel dilute olivaceis, septis inconspicuis, ad bases obconico-truncatis vel globosis, ad apices obtusis, 4–5 × 30–80 μ.

Leaf spots irregular, olivaceous to gray or dark brown to black blotches, 2–14 mm. in extent or sometimes coalescing into large areas, distinct border lacking; fruiting amphigenous but more abundant on the upper surface; stromata dark brown, globular, 20–40 μ or rarely elongated to 75 μ; fascicles mostly dense, rarely very dense; conidiophores pale to medium olivaceous brown, tips somewhat paler and often slightly swollen, 1 or 2 small spore scars, 1–6 septate, sparingly branched, undulate, or 1–3 geniculate, 3–4.5 × 10–80 μ; conidia obclavate to cylindro-obclavate, straight to nearly so, subhyaline to pale olivaceous, septa not distinct, bases obconically truncate to rounded, acute tips, 4–5 × 30–80 μ.

HABIT: On leaves of *Gonolobus laevis* Michx., Stillwater, Oklahoma, August 18, 1942. The first known collection of this fungus was made by George M. Reed at Columbia, Mo., October 1, 1910. The specimen was deposited in the herbarium at the University of Wisconsin. A description of the fungus has not previously been published.

TYPE: In the herbarium of the Department of Plant Pathology, Cornell University, No. *33133*.

3. **Cercospora Paspali** sp. nov.

Maculis ovatis vel linearibus, maximis 5 × 12 mm., atro-brunneis vel prope nigris, cebro cum centris angustissimis et alutaceis; fungis amphigenis; stromatibus cellis paucis tenus 30 μ diam., atro-brunneis; fasciculis cum 2–15 conidiophoris divaricatis; conidiophoris mediocriter brunneis sed ad apices pallidioribus et distincte attenuatis, 2–5 septatis, parce geniculatis, rectis vel tortuosis, non-ramosis, cicatricibus sporarum mediocribus ad apicibus sub-

truncatis, 3–4.5 × 10–80 μ; conidiis hyalinis, acicularibus vel prope cylindris, rectis vel nonnihil curvatis vel undulatis, indistincte pluriseptatis, ad bases truncatis vel obconico-truncatis, ad apices subacutis vel subobtusis, 1.2–4 × 30–140 μ.

Leaf spots oval to linear, the largest attaining 5 × 12 mm., dark brown to almost black, frequently with very narrow tan centers; fruiting amphigenous; stromata a few cells to 30 μ in diameter, dark brown; fascicles 2–15 divergent stalks; conidiophores moderately brown but paler and distinctly attenuated toward the tips, 2–5 septate, sparingly geniculate, straight to tortuous, not branched, medium spore scar at the narrow subtruncate tip, 3–4.5 × 10–80 μ; conidia hyaline, narrowly acicular to almost cylindric, straight to slightly curved or undulate, indistinctly multiseptate, truncate to obconically truncate at the bases, subacute to subobtuse at the apices, 1.2–4 × 30–140 μ.

HABIT: On leaves of *Paspalum stramineum* Nash, Perkins, Oklahoma, August 26, 1942. Perhaps this same species was collected by Hansford in Uganda, East Africa, on *P. scrobiculatum* L. No previous technical diagnosis, however, has been published.

TYPE: In the herbarium of the Department of Plant Pathology, Cornell University, No. *33134*.

4. **Cercospora Staphyleae** Ray & McLaughlin, sp. nov.

Maculis suborbicularibus vel angularibus, 0.5–4 mm. diam., cinereis vel albis, marginibus latis et atro rubro-brunneis, in inferiore superficie minus distinctis; fungis amphigenis; stromatibus atro-brunneis, globosis, cellis paucis grandis tenus 25 μ diam.; fasciculis cum 2–12 conidiophoris divaricatis; conidiophoris mediocriter brunneis sed proxime apicibus leviter pallidioribus, juste uniformibus in diametro, pluriseptatis, non-ramosis, rectis vel nonnihil curvatis, parce geniculatis, cicatricibus sporarum mediocribus ad apicibus subtruncatis, 4–6 × 30–150 μ; conidiis hyalinis, acicularibus vel per occasionem obclavatis, ad bases truncatis vel subtruncatis, ad apices acutis, 2–4 × 30–150 μ.

Leaf spots subcircular to angular, 0.5–4 mm. in diameter, gray to white, with wide dark reddish brown margins, less distinct on the lower surface of the leaf; fruiting amphigenous; stromata dark brown, globular, a few large cells to 25 μ in diameter; fascicles 2–12 divergent stalks; conidiophores medium brown but slightly paler near the tips, fairly uniform in diameter, multiseptate, not branched, straight to mildly curved, sparingly geniculate, medium spore scar at the subtruncate tip, 4–6 × 30–150 μ; conidia

hyaline, acicular or occasionally obclavate, straight to slightly curved, indistinctly multiseptate, truncate to subtruncate at the bases, tips acute 2–4 × 30–150 μ.

HABIT: On leaves of *Staphylea trifolia* L., Stillwater, Oklahoma, September 17, 1942.

TYPE: In the herbarium of the Department of Plant Pathology, Cornell University, No. *33135*.

5. **Cercospora daturicola** (Speg.) comb. nov.

Cercosporina daturicola Speg. Anal. Mus. Nac. B. Aires **20**: 425. 1910.

Cercospora abchazica Siemaszko, Bul. du Musée du Caucase **12**: 27. 1919.

The collection (No. *2877*) of this fungus was made at Pleasant Valley, Oklahoma, on September 1, 1942. According to Dr. Chupp this is probably the first report for North America. There appears to be some doubt concerning the presence of the TYPE specimen, but it may be in the collections of Spegazzini in the Museo Spegazzini, La Plata, Argentina, South America.

The Oklahoma collection is as described by Spegazzini for *Cercosporina daturicola*, except for a discrepancy with regard to the conidia. Those of our specimen are for the most part distinctly 6–7 septate, whereas Spegazzini describes them as having 3.

A specimen is deposited in the herbarium of the Department of Plant Pathology, Cornell University as No. *33131*.

The following recent collections of Cercosporae are deposited in the Cryptogamic Herbarium at the Oklahoma A. & M. College:

6. *Cercospora Arcti-Ambrosiae* Halsted.
   On *Ambrosia trifida* L., Perkins, Aug. 20, 1942, No. *2878*. Halsted's species is rare on this host.
7. *Cercospora biformis* Peck.
   On *Passiflora incarnata* L., McAlester, Aug. 27, 1942, No. *2879* and Stillwater, Sept. 17, 1942, No. *2880*.
8. *Cercospora Celosiae* Sydow.
   On *Celosia argentea* L., Stillwater, Aug. 18, 1942, No. *2881*. First report for North America; previously reported only from China, Brazil, and Venezuela.

9. *Cercospora Cephalanti* Ellis & Kellerm.
   On *Cephalanthus occidentalis* L., Stillwater, Sept. 17, 1942. No. *2882*.
10. *Cercospora Chrysanthemi* Heald & Wolf.
   On *Chrysanthemum maximum* Ram., Stillwater, Aug. 18, 1942, No. *2883*.
11. *Cercospora condensata* Ellis & Kellerm.
   On *Gleditsia tricanthos* L., Stillwater, Sept. 1, 1943, No. *2916*.
12. *Cercospora sojina* Hara syn. *Cercospora daizu* Miura
   On *Soja Max* (L.) Piper, Stillwater, Sept. 9, 1943, No. *2924*.
   In American literature *C. daizu* has been misspelled.
13. *Cercospora Diodiae* Cooke.
   On *Diodia teres* Walt., Perkins, Aug. 20, 1942, No. *2884*.
14. *Cercospora glandulosa* Ellis & Kellerm.
   On *Ailanthus glandulosa* Desf., Stillwater, Aug. 24, 1942, No. *2886*.
15. *Cercospora Lycii* Ellis & Kellerm.
   On *Lycium pallidum* Miers., Stillwater, Sept. 17, 1942, No. *2889*.
16. *Cercospora personata* (B. & C.) Ellis & Ev.
   On *Arachis hypogaea* L., Holdenville, Aug. 27, 1942, No. *2890*.
17. *Cercospora Physocarpi* Ray.
   On *Spiraea japonica* L., Stillwater, Aug. 18, 1942, No. *2896*.
   A new host record for this fungus.
18. *Cercospora rhoina* Cooke & Ellis.
   On *Rhus glabra* L., Stillwater, Aug. 18, 1942, No. *2894*.
19. *Cercospora salviicola* Tharp.
   On *Salvia azurea* Lam., Stillwater, Aug. 26, 1942, No. *2895*.

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A BIBLIOGRAPHICAL STUDY OF THE ICONES PICTAE SPECIERUM RARIORUM FUNGORUM OF CHRISTIAAN HENDRIK PERSOON

HARRY MORTON FITZPATRICK

(WITH 4 FIGURES)

Adoption of the Synopsis Methodica Fungorum, by the International Botanical Congress, as the starting point for nomenclature of the Ustilaginales, Uredinales and Gasteromycetes has caused that book to be more widely used in recent years than any other of Persoon's publications. The companion volume of hand colored plates prepared by him to illustrate some of the less common species described in the Synopsis is, in comparison, little known. This book bears the double title Icones Pictae Specierum Rariorum Fungorum in Synopsi Methodica Descriptarum a C. H. Persoon.—Figures Coloriées des Espèces Rares des Champignons Décrits dans l'Ouvrage Intitulé: Synopsis Methodica Fungorum par C. H. Persoon. It was published in four fascicles, each consisting of six plates with accompanying descriptive matter printed largely in duplicate in Latin and French. The entire work was published by Amand Koenig at Paris and Strasbourg.

For several reasons, this book has unusual bibliographical interest. It is one of Persoon's rarer works; to a surprising degree, copies of it have been preserved in an incomplete condition; and, quite generally, the date of publication of the last fascicle has been recorded incorrectly. We are concerned in this paper only with such bibliographical matters. Our statements are based on a critical study of the known copies of the work in North American libraries. It has been our privilege to examine several of them, and detailed knowledge of the others has been gained through correspondence. In the endeavor to locate as many specimens of the book as possible, and obtain information as to their state of completeness, a brief questionnaire was sent to a carefully selected list of mycologists and institutional libra-

rians. The response was very gratifying, and brought to our attention more than a dozen copies of which we had not previously known. This survey has been confined to the United States and Canada. We have little information concerning the work in libraries abroad.

Our interest in this rare old book was aroused by the discovery that the copy in the Cornell University library lacked the entire fourth fascicle, had no title page, and was incomplete in additional minor respects. Realizing that the missing portions could be photographed, and in particular that the colored plates could be reproduced by means of the recently developed processes of color photography, we borrowed another copy and set about completing our own. Having learned, meanwhile, of the existence of several other specimens of the book, also lacking the fourth fascicle, we placed a note in Mycologia (**35**: 256–257. 1943) in which we offered to prepare sets of prints for completion of such imperfect copies.[1]

Each of the four fascicles comprising the volume was provided originally with a cover of heavy gray or blue paper. The first page of the cover, in each instance, bears the complete title of the work in duplicate in Latin and French, carries the date and place of publication of the fascicle and gives the name of the publisher (FIG. 1). The second page bears a brief advertisement (FIG. 2), while the third is blank. The fourth provides a table of contents and an imprint giving the name and address of the printer (FIG. 3). As none of the material on these covers was

[1] All the photographs, except the two reproduced here as figure 1 and figure 3, were made by Mr. Willis R. Fisher of the Department of Plant Pathology at Cornell University. He has had years of experience in photographing botanical materials, and has been keenly interested in the preparation of colored prints from wash-off relief film. He is also skillful in hand-coloring ordinary prints. Both methods have been used by him in copying these colored plates. His prints match the original pages in size, and are wholly suitable for binding with them. Pages 45–64 and plates 19–24, comprising fascicle 4, all the pages of the four covers, and all the known half-title pages have been photographed. Though wartime limitations on photographic materials have handicapped us, we have been able to supply the missing pages for insertion in practically all of the known North American copies of this valuable old book. More than three hundred prints were required. We have completed seven copies which lacked the entire fourth fascicle, and have provided the various missing cover pages and half-title pages in the others.

ICONES PICTÆ
SPECIERUM
RARIORUM FUNGORUM
IN
SYNOPSI METHODICA DESCRIPTARUM
A
C. H. PERSOON.

FASCICULUS QUARTUS

FIGURES COLORIÉES
DES ESPECES RARES
DES
CHAMPIGNONS
DÉCRITS DANS L'OUVRAGE INTITULÉ:
SYNOPSIS METHODICA FUNGORUM
PAR
C. H. PERSOON.

QUATRIÈME LIVRAISON.

A PARIS et à STRASBOURG
CHEZ AMAND KŒNIG, LIBRAIRE.
1808.

FIG. 1. The first page of the colored paper cover of fascicle 4. Photograph of the copy in the Library of Congress obtained for us by John A. Stevenson. Letters actual size, but page of original is approximately 9 × 11 inches.

duplicated on sheets of white paper, copies of the book in which the covers are absent lack a title page and table of contents. Other books published at that period, with successive parts issued in similar colored paper covers, commonly contain pages on which the essential material on the covers in duplicated. This is true, for example, of Persoon's Icones et Descriptiones Fungorum Minus Cognitorum. In such cases absence of the covers is less important.

Though the date of publication of the first fascicle of the Icones Pictae Specierum Rariorum Fungorum appears on the cover as "An XI—1803," that of the second as "An XII—1804" and that of the third as "An XIII—1805," it will be noted (FIG. 1) that the date of fascicle 4 reads merely "1808." These Roman numerals on fascicles 1–3 constitute reckoning in terms of the years of the French Republic which was established in 1792. As Napoleon was declared Emperor in 1804 the reason for absence of reference to the Republic on the cover of the fourth fascicle can be readily surmised.[2] It is possible that the political situation in France was responsible for delay in the appearance of this fascicle, which might otherwise have appeared in 1806, and its absence in so many copies of the book today may have resulted from difficulties encountered in its distribution at that unsettled period.

The year of publication of fascicle 4 has been commonly recorded in the mycological literature as 1806. Pritzel (**5**) gives this date in both editions of his usually dependable Thesaurus Litteraturae Botanicae, and Lindau and Sydow (**4**) do the same in their Thesaurus Litteraturae Mycologicae et Lichenologicae. Brunet (**1**) in his well known reference work, Manuel du Libraire et de l'Amateur de Livres, not only cites the year 1806, but also states wholly erroneously that the work contains 39 plates and was published by Treuttel and Würtz. Graesse (**3**) in his Trésor de Livres Rares et Précieux ou Nouveau Dictionnaire Bibliographique agrees with Brunet on these various points except in

[2] One of our correspondents has called our attention to a similar use of Roman numerals, on recent numbers of Italian publications, to record the years of Mussolini's dictatorship. His prophecy that ere long this practice also would disappear seems well on the way to fulfillment.

questioning the number of plates, which he had noted is stated by Pritzel to be only twenty-four. The catalogue card of the Library of Congress is ambiguous. Though it states that the book appeared in four parts during 1803–1806, the date of publication of the whole is given as 1808. The copy of the volume in the library of W. G. Farlow at Harvard University contains in his writing the statement that the last part appeared in 1806. That year is given also by Edith Wycoff (6), librarian of the Lloyd Library, in her Bibliography Relating to Botany Exclusive

On trouve chez le même Libraire les Ouvrages suivans du même Auteur.

Synopsis methodica fungorum, 8. Gottingæ 1801. 11 fr.
Observationes mycologicæ, cum fig. color. pars I. et II. 8. Lips. 1796-99. 22 fr.
Icones et descriptiones fungorum minus cognitorum, 4. Lips. 1798. 24 fr.
Commentatio de fungis clavæformibus, cum fig. color. 8. Lips. 1797. 8 fr.
Commentarius Schaefferi fungorum Bavariæ indigenorum icones pictas illustrans, 4. Erlangæ 1800. 9 fr. 50 c.
Schaefferi fungorum qui in Bavaria et Palatinatu circa Ratisbonam nascuntur icones color. Editio nova, cur. Persoon, 4. Erlangæ 1800, 4 vol. 240 fr.

FIG. 2. Advertisement on page 2 of the colored paper covers of fascicles 1, 2, and 4. Reproduced here because it provides a check list of most of Persoon's other books, and is interesting in that it shows the moderate prices at which these great rarities were once sold. Two-thirds actual size.

of Floras. In her paper, Curtis G. Lloyd inserted a note which says "Persoon's Icones Pictae Fungorum, Icones et Descriptiones Fungorum, and Observationes Mycologicae are among the rarest works. M. Paul Klincksieck told me that in his thirty years' search for these works he had not secured copies. The volumes in the Lloyd Library were purchased at the sale of Oudemans' books, after his death."[3]

A letter recently received from E. W. Mason of the Imperial Mycological Institute at Kew states that the catalogue of the library of the British Museum of Natural History gives the dates of publication of the Icones Pictae Specierum Rariorum Fungorum as 1803–1806. He says further that the copy of the book

[3] The death of Oudemans occurred in 1906.

in the library of the Royal Botanic Gardens was not acquired until 1929. These bibliographical records would seem to indicate clearly that the book is rare, and that complete copies, including the fourth fascicle, have long been comparatively unavailable for consultation.

In response to our questionnaire, which sought to determine the number and condition of copies in North American libraries, replies were received from nearly seventy-five mycologists and librarians. Though these revealed that the volume is somewhat less rare in the United States than had been supposed, the more or less incomplete condition of all the copies was a distinct surprise. Ignoring a few fragments which contain less than the first three fascicles, we have located twenty copies of the work in North America. Twelve of these have all the text and plates of the four fascicles in the original. In the other eight the whole fourth fascicle was found to be lacking.

Unfortunately, the heavy, colored paper covers, in which the fascicles were issued, were discarded in almost all cases by librarians at the time of binding. In no single specimen of the book known to us were all of them retained. In three American copies, the covers of fascicles 1–3 inclusive are intact, and in one of these the front half of the cover of the fourth fascicle is also present. This copy is at the Academy of Natural Sciences of Philadelphia, and is the most nearly complete specimen of the book thus far encountered. It is the only one in which all four title pages are present in the original. Two other copies are outstanding in being the only ones in which page 4 of the cover, bearing the table of contents, was preserved for all four fascicles.[4] Not one of the twelve known copies of fascicle 4 has the entire cover in which it was issued. In two of the twelve, the back portion of the cover bearing the table of contents was retained, and in two others the front portion carrying the title page was saved. One of these two examples of the title page exists in the volume in the Library of Congress; the other is that in the Academy of Natural Sciences of Philadelphia. They both un-

[4] In one of these copies these tables of contents were cut out of the covers and pasted side by side on a single sheet of paper. The other copy has the pages in the original condition (FIG. 3).

questionably bear the date 1808. For complete verification of the point a photograph of the title page is reproduced here (FIG. 1). We are informed by E. W. Mason that the fourth fascicle in the library of the Royal Botanic Gardens at Kew also contains this title page with the date 1808. We have no reason

TABLE

Aecidium aquilegiæ.	Aecidie de l'ancolie, page 58, planche XXIII.
Aegerida pallida.	Aegerite pâle, p. 50, pl. XXI.
Agaricus venosus.	Agaric veineux, p. 46, pl. XIX.
Agaricus vulgaris.	Agaric vulgaire, p. 47, pl. XIX.
Diderma stellare.	Diderme étoilé, p. 56, pl. XXIII.
Hydnum rufescens.	Hydne roussâtre, p. 45, pl. XIX.
Isaria umbrina.	Isarie ombrinée, p. 51, pl. XXI.
Leotia mitrula.	Léotie mitrule, p. 54, pl. XXII.
Peziza repanda.	Pezize ondulée, p. 49, pl. XX.
Physarum contextum.	Physarie entrelacé, p. 55, pl. XXIII.
Sphæria biformis.	Sphérie biforme, p. 61, pl. XXIV.
Sphæria cirrosa.	Sphérie cirrheuse, p. 60, pl. XXIV.
Sphæria dubia.	Sphérie douteuse, p. 48, pl. XX.
Sphæria fimeti.	Sphérie fimétaire, p. 63, pl. XXIV.
Sphæria inquinans.	Sphérie noircissante, p. 62, pl. XXIV.
Sphæria podoides.	Sphérie podoide, p. 59, pl. XXIV.
Sphæria populina.	Sphérie du peuplier, p. 52, pl. XXI.
Sphæria ventricosa.	Sphérie ventrue, p. 64, pl. XXIV.
Stilbum citrinum.	Stilbe citron, p. 53, pl. XXII.
Uredo confluens.	Uredo confluente, p. 57, pl. XXIII.

A STRASBOURG, DE L'IMPRIMERIE D'AMAND KŒNIG.

FIG. 3. Table of contents on page 4 of the colored paper cover of fascicle 4. Photographed by J. T. Barrett from the University of California copy, which contains the only perfect example of this page known to us. Actual size. The imprint at the bottom shows that the fourth fascicle was printed at Strasbourg. The preceding three were printed at Paris.

to think that copies were distributed earlier, bearing the date 1806. Doubtless, the repeated mention of that year in the bibliographical literature resulted from the fact that, the first three fascicles having been published at yearly intervals from 1803 to 1805, it was assumed, in the absence of information to the contrary, that the fourth had followed in 1806.

Though no single copy of the book, as yet encountered, has been found to embrace complete specimens of all four fascicles, study of a considerable number of copies has made it possible to provide the following information with the conviction that it is correct in detail.

The first fascicle, as distributed, clearly included within its colored paper cover pages 1–14, plates 1–6 and three additional leaves. One of these extra leaves is of the nature of a binder's title page. It is printed in large letters on one side only with the following words: Icones Pictae Rariorum Fungorum.—Figures Coloriées de Champignons Rares. Though some librarians have used this for a title page, have written the name of the author on it, and have added information concerning the dates and places of publication, the page, as printed, bore no such data. The second leaf carries the preface, and stands between the binder's title page and the first page of the text. The prefatory material begins with the heading "Praefatio" on one side of the sheet, and ends with the words "Dabam Parisiis, mense Aprili. 1803. C. H. Persoon" on the other. The third extra leaf, bearing in large letters the words "Figures Coloriées" only, was clearly provided to stand before all the plates of the volume when these should finally be brought together at its end.

The second fascicle consisted of pages 15–28, plates 7–12, and a single additional leaf printed on one side only with the words "Figures Coloriées de Champignons Rares. Seconde Livraison" (FIG. 4). This was provided to serve as a half-title page for the fascicle.

The third fascicle included pages 29–44 and plates 13–18. Though a half-title page, bearing the words "Figures Coloriées de Champignons Rares. Troisième Livraison," should have been issued, we have failed to find a single specimen of it in any of the

twenty known American copies of the book. We now question whether the page was ever printed.[5]

The fourth fascicle comprised pages 45–64, plates 19–24, and a half-title page inscribed "Figures Coloriées de Champignons Rares. Quatrième Livraison."

When the four fascicles were assembled for binding as a single volume, they might well have been retained as units inside their individual covers, without rearrangement of their contents. Had this procedure been generally adopted all the uncertainty which has existed would have been avoided. Each fascicle would then

FIGURES COLORIÉES

DE

CHAMPIGNONS RARES.

SECONDE LIVRAISON.

FIG. 4. Half-title page of fascicle 2. In the bound volume it stands properly between pages 14 and 15 of the text. Two-thirds actual size.

have had its own title page and separate table of contents. The usual method consisted, however, in assembling all the pages of the text as a single series followed by all the plates. This arrangement would have proved satisfactory also, had all the covers been retained, since the tables of contents give indication of the exact limits of the several fascicles in the text and show which plates were issued with each fascicle. The dates of publication would also have been clear. Though not wholly necessary, retention of the half-title pages to mark the line between fascicles in the text would have made further use of these items

[5] Our suspicion that this sheet was not issued has been strengthened on learning of its absence in a copy of fascicle 3 with uncut leaves at the University of Michigan. If the sheet is discovered by one of our readers we would appreciate greatly being informed of the fact. We should like to learn also of the location of additional copies of the book.

also. As no title page was provided to serve for the whole volume, and as there is no general index or table of contents, it was imperative that all the covers be saved. While the position of the covers in the bound volume is not of great consequence, the ideal arrangement would seem to be that in which the four title pages are grouped together preceding the text and the four tables of contents are assembled following the plates.

In order that the student desiring to consult the book may readily locate a nearby copy of it, we provide below a list of American libraries in which the volume is known to exist. The arrangement is geographical. It will be noted that the copies are located chiefly in the northeastern United States in the older institutions. We realize, of course, that the list is probably not wholly complete. In particular, it is likely that volumes in the possession of private collectors have been missed.

Massachusetts Horticultural Society, Boston, Massachusetts
Boston Society of Natural History, Boston, Massachusetts
Farlow Library, Harvard University, Cambridge, Massachusetts
Biological Laboratories, Harvard University, Cambridge, Massachusetts
Brown University, Providence, Rhode Island
New York Botanical Garden, New York City
Cornell University, Ithaca, New York
Academy of Natural Sciences of Philadelphia, Philadelphia, Pennsylvania
Library Company of Philadelphia, Philadelphia, Pennsylvania
Library of John A. Stevenson, Beltsville, Maryland
Library of Congress, Washington, District of Columbia
University of North Carolina, Chapel Hill, North Carolina
Lloyd Library, Cincinnati, Ohio
University of Michigan, Ann Arbor, Michigan
University of Chicago, Chicago, Illinois
Missouri Botanical Garden, St. Louis, Missouri
State University of Iowa, Iowa City, Iowa
Iowa State College, Ames, Iowa
University of Minnesota, Minneapolis, Minnesota
University of California, Berkeley, California

In nineteen of these twenty copies, all four fascicles are now present. In seven of them the fourth fascicle is our photographic reproduction. The copy at the University of Michigan is in the library of Howard A. Kelly. That at the University of Minnesota is in that of E. W. D. Holway. The copy at the Academy of Natural Sciences at Philadelphia belonged earlier to B. M. Everhart, not, as might be supposed, to Schweinitz, whose herbarium is located there. Our attention has been called by Dr. F. W. Pennell to Benedict's account of Schweinitz's botanical library in Bartonia (**16**: 14–19. 1935) which indicates that Schweinitz did not own the Icones Pictae though he had four other books by Persoon. As Schweinitz and Persoon were contemporaries the point is of some interest.

CORNELL UNIVERSITY,
ITHACA, NEW YORK

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ALLESCHERIA BOYDII AND MONOSPORIUM APIOSPERMUM [1]

C. W. EMMONS

(WITH 9 FIGURES)

In 1922 Dr. C. L. Shear (**5**) published in this journal a description of a fungus isolated by Boyd and Crutchfield (**1**) from mycetoma of the foot. He named the fungus *Allescheria Boydii* and described an ascocarpic as well as byssoid and coremial conidial stages of development. This pathogenic fungus apparently has not been recognized since its original isolation although the name has been used in one instance (**2**) to designate a fungus similar except for the lack of ascocarps. *Monosporium apiospermum* Sacc. 1911, on the other hand, has been isolated from numerous cases of mycetoma. It bears a close resemblance to *A. Boydii*, but the similarity seems to have attracted little attention.

Recent observations in this laboratory demonstrate that *A. Boydii* is the ascocarpic form of *M. apiospermum*. Both fungi are etiologic agents of mycetoma of the foot, a mycosis characterized by swelling of the foot with sinus formation. The pus from a draining sinus contains small white granules composed of closely interwoven and radiating hyphae. Both fungi are gray byssoid molds, becoming olivaceous to brown with age and the formation of very numerous ovoid to egg-shaped or clavate conidia which are borne on simple or branching conidiophores. Coremia may or may not be formed. Several of the reported strains of *M. apiospermum* produced sterile sclerotia. In *A. Boydii* the corresponding structures are fertile ascocarps.

The fungus has a wide geographical distribution. The first strain of *M. apiospermum* known from Canada was isolated by Shaw and Macgregor (**4**) and described in detail by Dowding (**3**). It was received in this laboratory in December 1936 through

[1] From the Division of Infectious Diseases, National Institute of Health.

the courtesy of Dr. Dowding and has been carried in the culture collection since that time. During this interval important changes in its growth characteristics have occurred. Dowding observed that, unlike some isolates of the fungus, sclerotia were not produced by this strain. This was the case when the fungus was received from her, but in 1942 sclerotium-like bodies were observed in cultures. In subsequent transfers these structures appeared in increasing size and numbers and upon examination they were found to be fertile ascocarps. The ascocarps and ascospores resemble those described by Shear for *A. Boydii* except that the upper limit of size he reported has not been reached by any of the ascocarps measured. The conidia are like those reported by Shear for *A. Boydii* as well as like those characteristic of *M. apiospermum*. Coremia, as described by Shear, are rarely found and then only in rudimentary form (FIG. 1) in recent cultures of the Canadian strain although Dowding observed and described typical coremia at the time she studied it.

Many of the lower Ascomycetes, when carried in culture for years, lose the ability to produce ascocarps. This has occurred in the case of Dr. Shear's original strain of *A. Boydii* which, in this laboratory, has for many years produced only conidia of the *M. apiospermum* type. It appears probable that this ability, on the contrary, was acquired by the Canadian strain or that it reappeared. The possibility that the ascocarpic fungus was a contaminant seems remote since no other ascogenous strain of *Allescheria* has ever been carried in this laboratory. Three other strains of *M. apiospermum* carried in culture 7–10 years have not shown this method of sporulation.

In order to determine unequivocally whether the ascocarps observed in this old laboratory strain of *M. apiospermum* actually belonged to that fungus 150 single ascospores and 179 single conidia were isolated. This was accomplished by manipulations carried out for the most part within the field of view of a dissecting microscope under a magnification of 43 diameters. Small drops of sterile water were placed on the surface of cornmeal agar in a Petri dish. A single ascocarp was isolated, placed upon the agar surface, washed in a drop of water, then with a fine needle rolled across the agar surface from drop to drop of water, always

in the field of view of the microscope, until it was washed free of conidia. It was then removed to the agar surface in another Petri dish where it was crushed between two needles and the liberated ascospores were spread over the surface. This dish was incubated at 30° C. for 24 hours at which time most of the ascospores had germinated Isolated germinated ascospores were picked out with a fine needle under the dissecting microscope and transferred to agar slants. Four ascocarps were used in making 150 ascospore isolations. Germinated ascospores were definitely differentiated from any conidia which might have been carried over by accident on the perithecium by their elliptical shape, pointed ends and manner of germination which were still apparent at the time the transfer was made. All isolations from ascospores were alike.

The isolations from conidia were made by spreading over the surface of cornmeal agar plates a suspension of conidia taken from a young culture in which ascocarps had not yet appeared. Some conidia germinated in eight hours and after twenty hours nearly all had developed a branching mycelium. Single germinated conidia were picked out under a dissecting microscope in the manner described above for ascospores. All conidial isolates were alike.

Cultures made from the two types of spores produced colonies identical in appearance and in the production of conidia and ascospores. Both spore forms belong, therefore, to one and the same fungus. Since single spores invariably produced colonies bearing ascocarps in abundance the fungus is homothallic.

Except for the presence of ascocarps this strain is typical of other strains of *M. apiospermum* which have been described in reports and which have been studied in this laboratory. On cornmeal agar the aerial hyphae are scanty, gray and decumbent. The colony becomes brownish with the formation of conidia and ascocarps which, on this medium, are borne in most cases below the agar surface (FIG. 2). On acid dextrose agar [2] growth is abundant, floccose, mouse-gray, and the conidia and ascocarps are borne in profusion on the aerial mycelium and on the agar surface.

[2] Modified Sabouraud's agar: dextrose 4%, Difco neo-peptone 1%, agar 2%, pH 5.6.

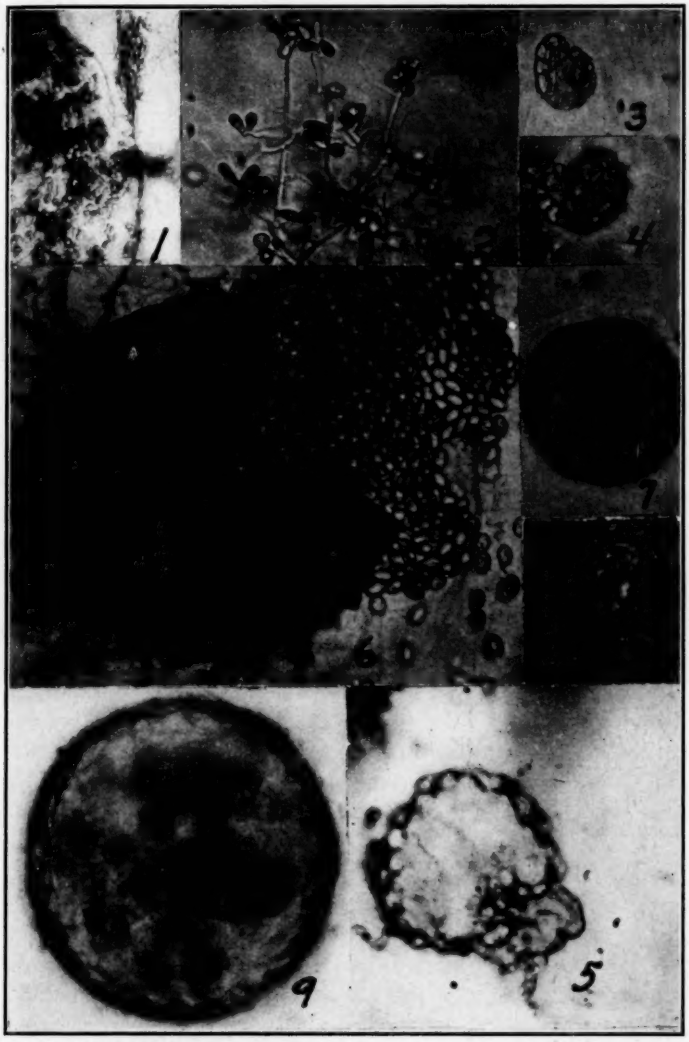

FIG. 1, Rudimentary coremium on dextrose agar; 2, conidia borne below the surface of the cornmeal agar; 3 and 4, young ascocarp with external ascogonial hypha persisting; 5, section of young asocarp with ascogonial complex external to perithecium; 6, ripe ascocarp and ascospores; 7 and 9, young small ascocarps with asci visible through the perithecium; 8, two young asci from a crushed ascocarp.

The conidia (FIGS. 1, 2) are borne single (rarely in groups or serially on the same conidiophore) at the tips or laterally on simple or branched conidiophores which vary greatly in length. They are elliptical, egg-shaped or clavate, occasionally subglobose, and have a truncate base. The walls are somewhat thickened and brown. The conidia vary greatly in size (3.5–6 × 5–10 μ), the measurements made in this laboratory being slightly less than those reported by Shear and Dowding.

The ascocarp is initiated by a coiled ascogonium. No differentiated antheridial cell could be definitely distinguished. The ascogonium remains visible for some time at one side of and external to a mass of small pseudoparenchymatous cells which produce the ascocarp (FIGS. 3, 4, 5). The first ascocarps to develop in a culture may reach a diameter of 130 μ (FIG. 6) which is smaller than the maximum size reported by Shear (200 μ). Ascocarps which develop later or under crowded conditions may mature when only 50 μ in diameter. The cleistocarpous perithecium is brown and is composed of a few cell layers so thin that asci and ascospores can be seen by transmitted light through the perithecium (FIGS. 7, 9). The asci are at first clavate (FIG. 8), becoming subglobose with the development of the eight ascospores (FIG. 7). They are so fragile that they are difficult to demonstrate in crushed mounts. The ascospores are elliptical with slightly pointed ends (FIG. 6). The walls are faintly brown. In the Canadian strain they measure 4–4.5 × 7–7.5 μ.

The author gratefully acknowledges an opportunity to show this fungus to Dr. C. L. Shear and discuss it with him.

SUMMARY

A strain of *Monosporium apiospermum*, when isolated from mycetoma of the foot, yielded only conidia. After it had been carried in culture for six years it began to produce ascocarps which were identified as those of *Allescheria Boydii*. Production of both conidia and ascospores in cultures derived from single conidia and single ascospores proved that the two spore forms belong to one fungus, that *A. Boydii* is the ascocarpic stage of *M. apiospermum*, and that it is homothallic.

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NOTE

In the preparation of this article the writer overlooked an important paper (Jones, J. W. & Alden, H. S., Maduromycotic mycetoma (Madura foot). Report of a case occurring in an American negro. Jour. Am. Med. Assoc. **96**: 256–260. 1931) in which an unusual strain of *Scedosporium apiospermum* (*A. Boydii* ?) was isolated. In the mycological section of the report, prepared in collaboration with Dr. F. D. Weidman, it was reported that sclerotia-like bodies found in cultures were perithecia containing spores. Probably because cultures of a suitable age were not examined asci were not observed. "It is evident that the fungus in question reproduces by means of spores not contained in asci or basidia and therefore must be classified as a Hyphomycete." *Allescheria* was not mentioned.

ISOGAMOUS SEXUALITY IN A NEW STRAIN OF ALLOMYCES [1]

HAROLD E. TETER

(WITH 3 FIGURES)

INTRODUCTION

Ever since the discovery by Kniep in 1929 of sexual reproduction and alternation of generations in the water mold, *Allomyces javanicus*, there has been considerable interest in the whole genus. Hatch (**1933**) found an identical cycle to be present in a fungus considered by him to be Butler's *A. arbusculus*. In both species gametophyte plants grew from swarmers released upon germination of the resistant sporangia of the sporophyte plant. Anisogametes released from the gametangia on the gametophyte fused in pairs to form zygotes which developed into sporophytes. Zoöspores derived from thin-walled sporangia on the sporophyte grew directly into new sporophytes.

Subsequent investigations have shown that there also exist strains of both of the aforementioned species which commonly pass through a short cycle involving the sporophyte only, the gametophyte being omitted altogether. In these cases the swarmers released from the resistant sporangia grow directly into new sporophytes. A third type of life history involving cyst formation was discovered by Emerson (**1938**). The nature of the life cycle in *A. moniliformis*, a species discovered by Coker and Braxton (**1926**), was found by Emerson in 1938 to be of this cyst forming type. Emerson did not describe this cycle in detail for *A. moniliformis*, merely stating that it was like that discovered by him in the species he later named *A. cystogenus*.[2]

[1] Contribution from the Department of Botany, University of Michigan, no. 735.

[2] Emerson first published his discovery of the *Cystogenes* type of cycle in 1938, but he did not erect the species *A. cystogenus* until 1941. In the interim, Indoh (1940) found in Japan a cyst forming strain which he considered to be the same as Emerson's material. He named it a new species calling it *A. neomoniliformis*. His name, therefore, takes priority over Emerson's if, as seems likely, the two fungi are found to be identical.

The most complete discussion of these three types of life cycles is to be found in Emerson's 1941 paper. Here, he calls them the *Euallomyces*, *Brachyallomyces*, and *Cystogenes* cycles, respectively.

The *Cystogenes* cycle is described by Emerson as consisting of a type of diplanetism within a short cycle. According to him the swarmers which leave the resistant sporangium are large, biflagellate, and quickly encyst. From these cysts uniflagellate swarmers, typically four in number, are said to emerge. These "secondary R. S. swarmers" are then reported to develop directly into normal sporophyte plants.

McCranie (**1942**), studying the same Burma 1-B strain with which Emerson did most of his work, contradicted Emerson on two important points. Firstly, he claimed a complete absence of flagella in the primary R. S. swarmers. Secondly, he claimed to have observed the secondary swarmers fusing in pairs to form biflagellate zygotes from which sporophyte plants developed. McCranie also emphasized the irregularity in size of the cysts and of the variable number of swarmers emerging from them.

In an attempt to resolve these points of variance regarding *A. cystogenus* and further to study this very interesting type of cycle, the present writer has been conducting observations on strains of two cyst forming species. Although this study is not complete, it is felt that the results obtained thus far are of sufficient significance to warrant this preliminary report.

MATERIALS AND METHODS

The two fungi which are the objects of the present investigation are *Allomyces cystogenus* Emerson and a new strain from Trinidad which resembles, in many respects, *A. moniliformis*. The material of *A. cystogenus* was from a sub-culture of the Burma 1-B strain first isolated by Emerson and used by him for most of his work on the cyst forming cycle (**1941**: 84). It was sent by him to Dr. F. K. Sparrow, who gave it both to McCranie and to the author. The strain is remarkable for the ease with which its resistant sporangia can be induced to germinate. The Trinidad fungus was isolated by Dr. F. K. Sparrow from dry soil brought to him by Dr. W. R. Taylor from a rice paddy near the asphalt pits of Trinidad, B. W. I.

Observations were made on material mounted in hanging drop cultures. In the cyst-forming species of *Allomyces* the resistant sporangia are strongly deciduous. It was a simple matter, therefore, to draw into a capillary tube some of these bodies which had fallen to the bottom of old water cultures and to transfer them to cover slips. These slips were then inverted onto glass rings to form hanging drop cells. The Burma 1-B strain needed no further inducement to germinate, and the whole process was watched many times as it occurred in these cells. This method differed somewhat from Emerson's, who, apparently, used resistant sporangia taken from pure agar cultures. It differed from McCranie's with respect to the use of hanging drops. McCranie placed his material directly on microscope slides with supported cover slips over the top.

With the Trinidad strain, germination of resistant sporangia was induced by placing them in fresh water in a watch glass and leaving them at 4° C. for a day or two. The watch glass was then brought back to room temperature and some of the resistant sporangia removed to cover slips, where they were dried down for a day or more before wetting and mounting in hanging drops. Even then, germination was uncertain, so that some phases of the cycle were seen only once or twice.

All the molds were grown in boiled hemp seed in sterile water. The cultures were unifungal and reasonably clean. No attempt was made, however, to rid them of bacteria.

OBSERVATIONS ON AN ALLOMYCES FROM TRINIDAD

As previously stated, the resistant sporangia of this species are not easily induced to germinate, and, although all stages in the life history were observed, some of them were seen only once or twice. There was no indication, however, that the observed behavior was anything but typical.

The most remarkable feature of this strain was that so far as could be determined all of its swarmers were completely devoid of flagella. They moved about in a weakly amoeboid fashion, never getting far from their place of origin. In asexual reproduction the thin-walled zoosporangia developed escape papillae which deliquesced to form pores through which the amoeboid

zoöspores emerged. These spores were comparable in size (8 × 11 μ) and general appearance to other swarmers of the genus, but no flagella could be seen either in living examples or in ones which had been killed and stained. Their movements were far less effectual than the amoeboid locomotion often resorted to by the flagellate swarmers of other species. Although the swarm period of these zoöspores was probably of normal duration they usually failed to progress more than three or four hundred microns before encysting and sending out rhizoids.

Repeated emergence of encysted zoöspores seemed to be of normal and frequent occurrence. It was also found that even

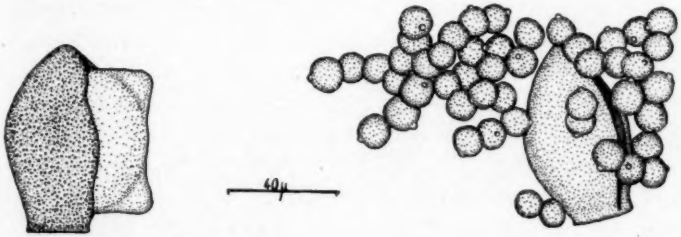

FIG. 1. The Trinidad isolate of *Allomyces*. *a*. The germinating resistant sporangium. The contents have swelled out and formed two escape papilla. *b*. Cysts formed by the amoeboid "primary R. S. swarmers."

after a fairly extensive rhizoidal system had developed on the encysted zoöspore, a somewhat undersized swarmer might emerge from the cyst and go through another period of amoeboid swarming before again encysting. After emergence the empty cyst wall, with or without rhizoids, was always left behind.

This phenomenon of repeated emergence, although common among certain other water molds, is apparently of less frequent occurrence in *Allomyces*. The only previous record of such behavior in encysted and ungerminated zoöspores, known to the writer, is to be found in the plate accompanying Coker and Braxton's paper (**1926**) describing *A. moniliformis*. This figure shows what is labeled as a spore "escaping from cyst." The text, however, makes no mention of this and describes the zoöspores as monoplanetic. Emerson (**1941**) notes this as a discrepancy between the text and figure and concludes that what Coker and

Braxton actually saw was cyst formation by planonts derived from resistant sporangia. In view of the frequency with which repeated emergence was observed in the Trinidad strain it would seem that the Coker and Braxton figure does, in fact, refer to zoöspores. Likewise, the designation of "monoplanetic" is correct, for repeated emergence is not true diplanetism in the commonly accepted sense of the term. The Saprolegniaceae, for instance, are considered truly diplanetic because in some genera the swarmers regularly form, as an essential part of the life history, cysts which give rise in turn to secondary swarmers different in their morphology from the primary ones. In cases of repeated emergence, on the other hand, a spore which would

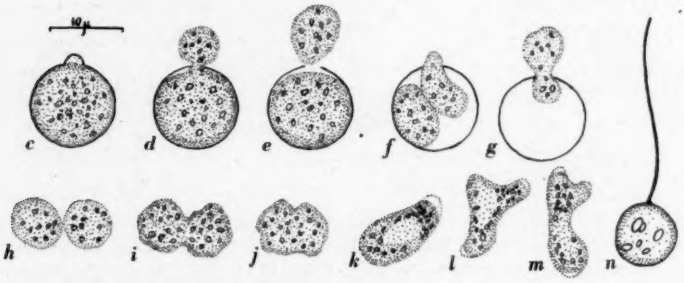

FIG. 2. Trinidad isolate of *Allomyces*. *c*. A cyst formed by a "primary R. S. swarmer." *d, e*. First amoeboid gamete escaping from cyst. *f*. Third gamete starting to escape. *g*. Fourth gamete emerging. Empty cyst left behind. *h, i, j*. Stages in the fusion of two gametes. *k*. Typical aspect of zygote. *l, m*. Irregular shapes sometimes assumed by zygote in its amoeboid movement. *n*. Encysted zygote putting out a germ tube.

normally encyst and develop directly into a new plant fails to do so, due to special conditions such as starvation. Instead, the protoplasm organizes itself once more as a swarmer (or swarmers in some species) and emerges to seek further for a suitable substrate. A good example of such repeated emergence is to be found in Sparrow's paper (**1931**) on *Pythium adhaerens*. In the Trinidad strain, the term "repeated emergence" can be used only in referring to those cases where the new swarmer emerges before any rhizoids have formed. The functioning of tiny germlings as zoösporangia has been reported by Emerson (**1931**) for all species of *Allomyces*.

Although the amoeboid, non-flagellated nature of the zoöspores in the Trinidad fungus gave every appearance of being a normal manifestation, it seemed possible that, as has been found to be the case in other water fungi, environmental factors might be responsible. To check this possibility two series of cultures were started, one of a North Carolina strain of *A. moniliformis*[3] and one of the Trinidad strain. Sterile water from the same flask was poured into identical dishes. The same number of boiled hemp seeds was introduced into each, and each was inoculated by placing a tuft of fungous filaments near the seeds. The two series of cultures were kept side by side to eliminate the possibility of temperature differentials. Growth in both cultures seemed normal and vigorous. After eleven days, filaments were removed from both cultures and placed in hanging drops. The thin-walled sporangia of the North Carolina material gave rise to normal, flagellated zoöspores. Those of the Trinidad strain produced only amoeboid types.

The sequence of events in the germination of the resistant sporangium of the Trinidad fungus was followed. The first sign of germination is the appearance of a longitudinal split along one side of the outer pitted sporangial wall. The sporangial contents, covered by the thin, inner wall, swell out through this opening to form a structure about double the original volume. The outer wall remains, clasping this enlarged structure on one side (FIG. 1, *a*). Soon escape papillae form which, upon maturity of the structure, deliquesce simultaneously. Through the openings thus produced the fully formed planonts escape rapidly. These planonts are what Emerson calls the "primary R. S. zoöspores." They are without flagella and average about 11.5 μ in diameter when spherical. When in motion they are ellipsoidal. Their movement is strongly amoeboid. They are, in fact, capable of more effective movement than any of the other types of swarmers observed in this strain. Their activity is short lived, however, for they soon round up and encyst (FIG. 1, *b*). Oftentimes the first ones to emerge have already encysted before

[3] This is the North Carolina strain 3 of Emerson (**1941**). It was given to the writer by Dr. F. K. Sparrow, who obtained it from Dr. J. N. Couch.

the last ones escape. The cysts may either remain quiescent for several hours, or they may germinate within an hour.

These cysts are, in reality, miniature gametangia. Each forms a single exit papilla (FIG. 2, *c*) which deliquesces to allow the escape of four isogamous amoeboid gametes (FIG. 2, *d–g*), each typically about 9.5 $\mu \times 6.5\ \mu$. They emerge from the cyst singly and crawl about with an extremely weak amoeboid motion in the immediate vicinity of the exit pore. It may take several

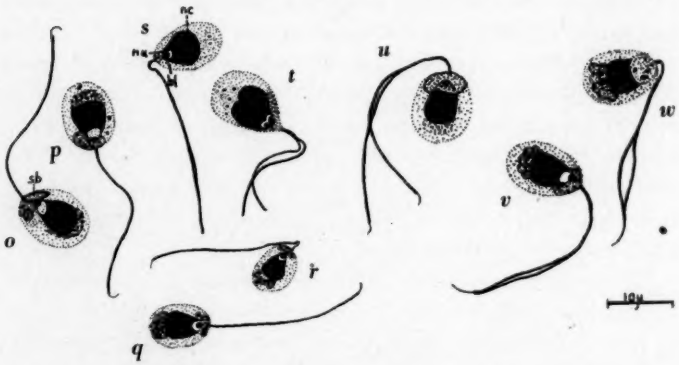

FIG. 3. Stained planonts of *Allomyces cystogenus*. *o*, *p*. Zoospores stained by the wet gentian violet method. *sb*. Structure possibly corresponding to "side bodies" found by Couch and Whiffen in *Blastocladiella*. *q*, *r*. Gametes stained by the wet gentian method. "*q*" is of normal size for gametes. *s*, *t*. Zygotes stained by the dry gentian violet technique. In "*t*" the nuclei have not yet completely fused. *nc*. Nuclear cap. *nu*. Nucleus *bl*. Blepharoplast. *u*. Zygote stained by wet safranine. *v*, *w*. Zygotes stained by the wet gentian violet method.

minutes for a gamete to progress a single length forward. All of the forty or more cysts from a single resistant sporangium germinate simultaneously. As a result, the numerous gametes thus released soon become so thoroughly intermingled that it is impossible to trace with certainty the place of origin of any particular gamete. It cannot be definitely said, therefore, whether or not gametes from a given cyst are compatible. Preliminary observations seem to indicate that they are not.

As the gametes move weakly about they come together in pairs and fuse (FIG. 2, *h–j*), a process which may be accomplished

smoothly and quickly or be a more protracted one involving much preliminary contracting and jerking. Because of the limited powers of locomotion of the gametes it is often a matter of a few hours before all have found mates. The zygotes (FIG. 2, *k–m*) are similar in size, appearance, and behavior to the ordinary zoöspores formed in the thin-walled zoösporangia. They undergo a period of weak amoeboid locomotion after which they come to rest, encyst, and put out a germ tube (FIG. 2, *n*). In this manner a new generation is established. One or two cases of repeated emergence of the zygote were observed.

The life cycle of the Trinidad strain of *Allomyces* can be summarized as follows: The mature plant produces two kinds of reproductive structures, (A) thin-walled zoösporangia, and (B) thick-walled resistant sporangia.

A. The zoösporangia give rise to numerous amoeboid zoöspores, each of which may grow into a new sporophyte plant, with or without passing through repeated emergence first.

B. The resistant sporangia can survive drying and serves, therefore, to carry the species through periods of adverse environmental conditions.

1. When resistant sporangia finally germinate, amoeboid "primary R. S. swarmers" are produced.

2. These swarmers quickly encyst, the cyst constituting a much reduced gametophyte.

3. Each cyst discharges four equal-sized, non-flagellated gametes.

4. The gametes fuse in pairs to form zygotes.

5. After a swarm period the zygotes may encyst and go through repeated emergence or more commonly, germinate directly into new sporophyte plants.

One further feature of interest was noted. It was repeatedly observed that mycelia of the Trinidad isolate exhibited a capacity for conserving protoplasm in severed hyphae. This has frequently been observed not only in this species but in the others of the genus as well. It is probable that many workers must have seen this phenomenon but apparently none has recorded it. When filaments of the fungus are removed from a hemp seed and placed in a hanging drop they have, of course, been cut off from

their food supply. Furthermore, the coenocytic hyphae have been severed near the base and a certain amount of protoplasm runs through the broken end. This "bleeding" is not as extensive as might be expected, however, for the plant is able to retain a surprisingly large proportion of its protoplasm. The pseudosepta are probably an important factor in checking the escape of the hyphal contents, for one often sees concentrations of protoplasmic material crowded on one side of a septum. At all events, the plant is left with much of its protoplasm and included food reserves (mainly fat globules) still intact. In some instances its reaction to this injury may be the production of numerous new hyphae which seek out possible sources of nutrition. Usually, however, the tendency of such injured hyphae is to conserve the now isolated protoplasm by drawing it together into several chumps within the filament, each of which subsequently develops into a zoösporangium. These sporangia may be terminal or in chains, as is typical of the species, or they may be intercalary and isolated from one another. This ability of protoplasmic fragments under certain conditions to form zoösporangia is of obvious survival value to the fungus.

Definite identification of the Trinidad fungus with an already described species has been avoided. In general morphology it closely resembles *Allomyces moniliformis* Coker & Braxton (**1926**). Its pointed resistant sporangia, its zoösporangia of variable length, and its *Cystogenes* type of life history would place this fungus in the Coker & Braxton species. The amoeboid planonts of the Trinidad strain, however, set it apart from this and all other species of *Allomyces*. Nevertheless, the writer hesitates to erect a new species on this single character until further experimentation and observation establish beyond question that under no conditions are flagella ever formed. Should it be found possible to induce the formation of flagella, the strain could be considered to be no more than a variety of *A. moniliformis*.

CONFIRMATION OF ISOGAMY IN ALLOMYCES CYSTOGENUS

The life cycle of *Allomyces cystogenus* (Emerson's Burma 1-B strain) proved to be in every way similar to that of the Trinidad fungus save for the fact that the swarmers were flagellate. As

already described by both Emerson (**1938**, **1941**) and McCranie (**1942**), the outer wall of the resistant sporangium splits, usually across the rounded end and down each side. The protoplasmic contents within the elastic inner wall then swell out through this split and soon form escape papillae. Some cases were observed in which the contents slipped completely free of the outer wall of the resistant sporangium and assumed a spherical form out in the water. The "primary R. S. swarmers" are released upon the deliquescence of the papillae.

The planonts which emerge from the resistant sporangia are typically of rather uniform size, averaging, when spherical, 11.5 μ in diameter. At times, especially when there was reason to suspect that the oxygen content of the water was low, the planonts were very unequal in size, ranging from seven to over thirty microns in diameter. Since McCranie observed his material under a supported cover slip, where the water would probably be poorly supplied with oxygen, it is not surprising that he considered variability in size to be typical of these swarmers. It is likewise understandable that Emerson should have found uniformity to be the rule, for he transferred his material from pure agar cultures directly to hanging drops where an abundance of oxygen would be available. The presence or absence of flagella on these swarmers seems, likewise, to be conditioned by culture methods. Emerson found them uniformly biflagellate whereas McCranie asserted that they were amoeboid and lacked flagella completely. The writer, with methods which might be considered to be intermediate between the others so far as aeration was concerned, found the amoeboid, non-flagellate condition common. In many cases, however, planonts were observed under these conditions which bore one to four or more flagella. The flagellar action of these planonts was never more than an uncoordinated threshing about. Movement of any sort was of very limited duration. Frequently the first group of spores to emerge came out as a shapeless mass which quickly rounded up into numerous discrete bodies. These often encysted at once without further movement. The remaining swarmers, with or without flagella, emerged successively by amoeboid movement and soon they, too, became encysted. Often the first ones to escape encysted so near

the opening of the sporangium that they trapped those remaining inside. These entrapped swarmers could frequently be seen crawling about for a considerable length of time before they, too, rounded up and encysted.

The cysts thus formed function as small gametangia, just as they do in the Trinidad fungus. Each develops a single escape papilla which deliquesces to allow the uniflagellate gametes to emerge. These bodies average about $9.5 \times 6.5\ \mu$. Although they are active and capable swimmers, they seldom move far, tending, rather, to stay in the immediate vicinity of the cysts. The greater number of these cysts measure $11.5\ \mu$ in diameter. Each gives rise uniformly to four gametes. Other cysts, either larger or smaller than these typical ones, produce numbers of gametes proportionate to their sizes. Since the volumes of spheres vary directly as the cubes of their radii, it is possible to predict with accuracy how many gametes can be expected from a cyst of a particular size. As a result of the fact that all the cysts from one resistant sporangium germinate within a few minutes of each other, there is produced a large mass of gametes which swarm about and crawl over one another in a most confusing manner. It is frequently difficult, therefore, to follow the sequence of their activities.

By carefully following the movements of individual gametes it is possible to observe actual fusion. Two gametes will come together, glide about amoeboidly over one another, and finally merge. The flagella come to lie side by side and act as one, so that the living zygote appears to be uniflagellate. These zygotes look and act like typical *Allomyces* zoöspores. After a swarm period they come to rest, lose their flagella, encyst, and send out germ tubes. Many times several gametes simultaneously come together and crawl over one another, making it difficult to see which ones finally fuse. Often two gametes which appear to be fusing will suddenly jerk apart as though they were incompatible. The time taken for actual fusion varies, seemingly being dependent upon the relative positions of the gametes when they first make contact. If they lie side by side with flagella parallel, their bodies flow together effortlessly, and the zygote swims away within a minute or less. When the gametes are not so well

aligned at the outset, several minutes of violent threshing about may ensue before the two flagella come to lie parallel and function as one.

In order to study more carefully the various planonts of this fungus, gametes, zygotes, and ordinary zoöspores were killed and stained. The swarmers, in drops of water, were killed by exposure to osmic acid fumes. Some were dried down in aqueous gentian violet, destained in clove oil and orange G, and mounted in balsam (Cotner's method). Others were observed at once after staining in weak aqueous solutions of gentian violet or safranin (Couch and Whiffen **1942**). The first method yields inferior results in that it leads to shrinking and distortion. Furthermore it fails to show as much cellular detail as when Couch's method is followed. The cell contents as revealed by Cotner's method consist of a large, deep staining, nuclear cap at the base of which is the lighter nucleus (FIG. 3, *s*, *t*). The latter contains at its base a dark staining object, probably a blepharoplast, which is intimately connected with the flagellum. Couch's method (FIG. 3, *o–r*, *u–w*) shows, in addition to these parts, the food globules so prominent in living material. These stain moderately with the gentian violet but only slightly with safranin. This method also reveals about the base of the cell an irregular mass of material which may well correspond to the "side body" found by Couch and Whiffen (**1942**) in swarmers of *Blastocladiella* (the "Zeitenkörper" of Stüben, **1939**). In *A. cystogenus* this structure never extends so far up the side of the cell as was found by Couch and Whiffen to be the case in *Blastocladiella*. Indeed, it seldom extended much above the top of the nucleus (the flagellated end is here considered the basal end, or "bottom" of the cell). For this reason the identification of this structure in *A. cystogenus* with the "Zeitenkörper" of Stüben and "side body" of Couch and Whiffen must remain tentative for the time being. The zygotes, in all cases, showed two flagella, although these, even in stained mounts, were often so closely appressed laterally as to appear as one. Evidently the nuclear caps, nuclei, and blepharoplasts of the gametes all fused, so that only one of each of these structures was to be found in the zygote. Cases were found where the staining technique had caught the fusion

in progress (FIG. 3, *t*). In size, appearance, and behavior, there is nothing to distinguish the zygote from the zoöspore save, of course, its double flagellum.

DISCUSSION

It becomes apparent, as Emerson has pointed out, that the life cycles here described represent a shortening of the *Euallomyces* type of cycle. The cyst probably represents a much reduced gametophyte generation, for like a gametophyte, it is derived from a "R. S. swarmer" and gives rise to gametes. We can consider, therefore, that in the *Cystogenes* type of cycle the gametophyte is reduced to a single gametangium, the cyst. It might be contended that the *Brachyallomyces* cycle represents a still further simplification in which the gametophyte is suppressed altogether. The *Cystogene* cycle would, then, be the transitional type. That such is not the case is indicated by the readiness with which some strains of the *Brachyallomyces* type revert, under proper conditions, to a long cycle (see Emerson, **1941**). Furthermore, the strains of the *Brachyallomyces* and *Euallomyces* types are indistinguishable morphologically, whereas the *Cystogenes* types can, as Emerson has shown, be recognized not only by their life histories but by certain structural features as well. Among these are coarsely pitted resistant sporangia and, in *A. moniliformis*, pointed ends to the resistant sporangia.

A most remarkable parallelism in behavior is to be found between *A. cystogenus* and *Blastocladiella cystogena* as reported by Couch and Whiffen (**1942**). The cyst formation, gametic fusion, and zygote behavior (two flagella lying parallel and functioning as one) are so nearly identical that a description for one could easily serve for the other.

In one respect the behavior in *A. cystogenus* differs from that in *Blastocladiella cystogena*. Couch states that the planonts which emerge from the resistant sporangium in *B. cystogena* are uniflagellate. In *A. cystogenus*, on the other hand, the number of flagella may vary from none to several. Emerson, as we have seen, considers two flagella to be the normal number under optimum conditions. McCranie denied the existence of any flagella. The author is inclined to accept Emerson's conclusions

on this point, for he did not exactly duplicate Emerson's methods (nor are they, in all probability, ever duplicated in nature). It seems likely that the number of these flagella present on the "R. S. swarmer" may represent the number of nuclei in its cytoplasm. This would suggest the possibility that the first meiotic division of gametogenesis takes place in the "R. S. swarmer" prior to its emergence from the resistant sporangium and that the second division takes place in the cyst. Cytological evidence will be needed to prove or disprove this hypothesis.

In connection with the observations on the Trinidad strain herein described it is of interest to note how few records exist of nonflagellate spores among the uniflagellate aquatic Phycomycetes. *Amoebochytrium rhizidioides*, seen once by Zopf (**1884**), has nonflagellate spores capable of amoeboid motion. *Sporophlyctis rostrata* Serbinow (**1907**) and *Sporophlyctidium africanum* Sparrow (**1938**) have spores without flagella and apparently incapable of any sort of movement (aplanospores). Thus, of the many species of the uniflagellate series of aquatic Phycomycetes now known, only four produce aflagellate spores, and, of these, only two exhibit amoeboid movement.

Since this study has added still others to the various types of planonts already known for the genus *Allomyces* the following tabulation is presented as a convenient summary. It will be noted that twelve distinct types of swarming bodies are found among the various species. The number found in any one strain ranges from two to five. It will be further noted that no one type is common to all strains. While pointing out the differences between the various planonts it should be borne in mind that all types are very similar in internal structure.

TYPES OF PLANONTS FOUND IN THE GENUS ALLOMYCES

Euallomyces Type—*A. arbusculus*, *A. javanicus:*

1. Zoöspore (uniflagellate, 8 × 11 μ) from thin-walled zoösporangium on the sporophyte. Germinates to form another sporophyte.

2. Uniflagellate spore from the resistant sporangium of the sporophyte. Germinates to form a gametophyte.

3. Female gamete (uniflagellate) from female gametangium on the gametophyte. May sometimes develop parthenogenetically into a gametophyte.

4. Male gamete (uniflagellate; half as big as 1, 2, and 3 above) from male gametangium of the gametophyte. Fuses with female gamete in the water.

5. Zygote (biflagellate). Germinates to form a sporophyte.

Brachyallomyces Type—*A. anomalus:*

1. Zoöspore (same as 1 above).

2. Spore from a resistant sporangium. Like 2 above except that it grows into a sporophyte.

Cystogenes Type

A. *A. cystogenus, A. moniliformis:*

1. Uniflagellate zoöspore. Like 1 in *Euallomyces.*

2. "Primary R. S. spore." Typically biflagellate (?). Forms cyst 11.5 μ in diameter.

3. Uniflagellate isogametes (9.5 μ). From cyst (usually four in a cyst).

4. Biflagellate zygote. Equal in size to a zoöspore. Germinates to form a sporophyte.

B. The Trinidad Isolate:

1. Amoeboid, aflagellate zoöspore.

2. Amoeboid, aflagellate "primary R. S. swarmer." Forms cyst which gives rise to four gametes.

3. Amoeboid, aflagellate isogametes. Fuse to form zygotes.

4. Amoeboid, aflagellate zygote. Germinates to form a sporophyte.

SUMMARY

1. Since Emerson's discovery of a cyst-forming cycle in *Allomyces cystogenus* (*A. neomoniliformis*), McCranie claims to have found sexual fusion to be present between the isogamous "secondary R. S. swarmers." This is in contradiction to Emerson. To resolve the argument two species of the cyst-forming type were studied, one a subculture of Emerson's *A. cystogenus* and the other a new strain from Trinidad resembling *A. moniliformis.*

2. In the Trinidad strain "primary R. S. swarmers," gametes, zygotes, and zoöspores, were found to be amoeboid and devoid of flagella.

3. The fusion of isogamous gametes was observed many times in both species and appears to be the rule. McCranie's statement that no flagella ever occur on the primary swarmers could not be substantiated, although the "typical" number of these flagella remains in some doubt.

4. The general morphology of the swarmers was studied.

5. The almost perfect parallelism between the life cycles of *Allomyces cystogenus* and *Blastocladiella cystogena* (Couch and Whiffen, **1942**) is pointed out.

ACKNOWLEDGMENTS

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SPERMATIAL FORMATION IN GYMNOSPORANGIUM CLAVIPES

LINDSAY S. OLIVE

(WITH 2 FIGURES)

Since Blackman (**1904**) presented what appeared to be a rather complete account of spermatial formation in *Gymnosporangium clavariaeforme* Rees, little has been added to his description. The present writer has chosen for investigation *Gymnosporangium clavipes* Cooke & Peck, a species which has exceptionally large spermagonia (FIG. 1) and spermatial hyphae. This rust occurs abundantly in our area, with its spermagonia and aecia on *Amelanchier*, *Choenomeles* and *Crataegus*, and its telia on *Juniperus virginiana*.

Diseased fruits of *Amelanchier* showing fresh spermagonia over their surfaces were collected and placed in formalin-acetic-alcohol solution. Various stains were used, including iron-alum haematoxylin, safranin and gentian violet, and Flemming's triple stain. Practically all of the drawings were made from material treated with the triple stain, which seemed the most effective.

Upon careful examination of the spermatial hyphae, it was discovered that there is an open collar at the tip of each hypha, and that the spermatia are budded off through this opening (FIG. 2: 1–14). The young bud first pushes its way up through the opening of the collar (FIG. 2: 1–3) and enlarges just above the rim of the collar (FIG. 2: 4–8). In the meantime, nuclear division occurs in the spermatial hypha and a nucleus passes up into the developing spermatium, as Blackman (**1904**) has already described in detail. The mature spermatium is cut off by constriction at its base (FIG. 2: 9, 12, 13), not by the formation of a cross wall between it and the tip of the hypha, as Blackman described for *G. clavariaeforme*.

The next spermatial bud appears very soon after the preceding one is constricted off and displaces the latter from the mouth of the collar (FIG. 2: 10, 11). Occasionally the spermatia may be

found still clinging together in chains of two or three (FIG. 2: 12, 13). Figure 14 shows the collar at the tip of a spermatial hypha, from which the spermatia have been dislodged. The diameter of the collar's opening is variable, as can be seen in the figures. Moreover, the collar wall is generally thickened and takes the orange gold stain quite well. The thickness of this wall is variable, as the drawings indicate. Blackman (**1904**), in

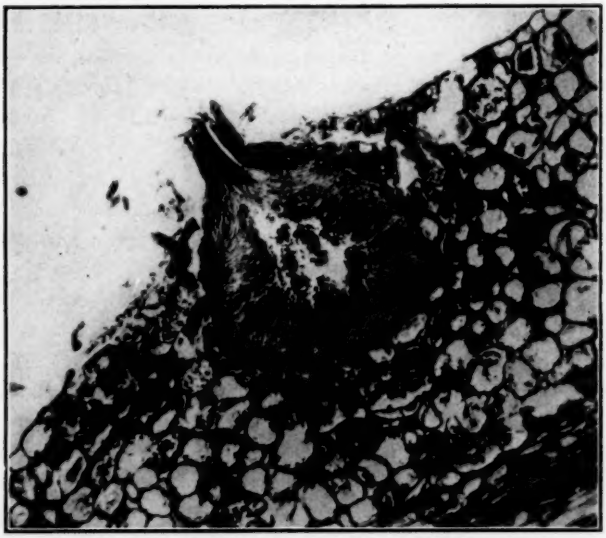

FIG. 1. Section through spermagonium of *Gymnosporangium clavipes* on fruit of *Amelanchier*, × 100.

describing the spermatial hypha in *G. clavariaeforme*, stated: "It is furnished at the free end with a curious ring of thickening, which is easily rendered visible by the fact that it takes Congo-red with more avidity than the rest of the cell-wall." He illustrated the ring-like thickenings in his drawings of the spermatial hyphae, but evidently did not observe that they were actually open collars through which the spermatia are budded.

It appears from the foregoing observations that the spermatium is primarily a uninucleate naked cell which originates as a bud from the protoplasm at the base of the collar. On the other hand, Craigie (**1933**), Allen (**1933**) and others have shown that

when the spermatium fuses with a receptive hypha, an empty cell wall is left outside the hypha after its contents have emptied into the latter. However, most or all of this cell wall appears to be laid down after the spermatium has been discharged from the

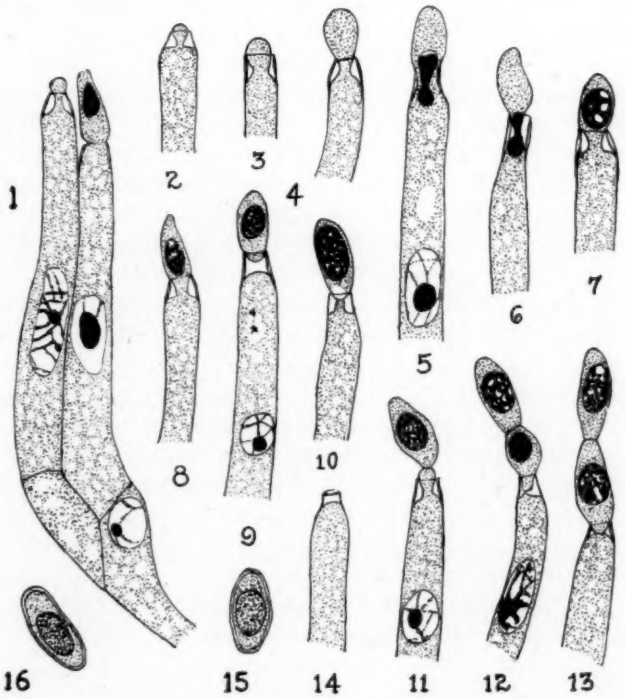

FIG. 2. *Gymnosporangium clavipes*. 1–14, steps in the production of spermatia from the spermatial hyphae; 15, 16, spermatia with cell walls, found on surface of *Amelanchier* fruit, × 1825.

hypha which produces it. Indeed, there does not appear to be a cell wall around any of the spermatia in the cavity of the spermagonium, where they are surrounded by a liquid medium of nectar. On the other hand, a thin cell wall may be seen around some of the spermatia among the paraphyses, while there is a very conspicuous cell wall around those spermatia which have been discharged over the surface of the *Amelanchier* fruit (FIG. 2:

15, 16). Thus the formation of the cell wall around the spermatium appears to be a secondary phenomenon, associated with the transfer of the spermatium from a liquid medium to the air.

It is interesting to note that the method of spermatial formation in *G. clavipes* is like that found in various Ascomycetes by a number of investigators. Essentially the same method has been observed by Thaxter (**1896**) in the antheridia of the Laboulbeniales and by Whetzel (**1937**, **1942**) in the spermadochia of *Septotinia* and *Martinia*, respectively. Brierley (**1918**) found a strikingly similar method in the formation of microconidia in *Botrytis cinerea*, while Dodge (**1932**) observed a slight modification of this method in the production of microconidia in *Neurospora sitophila*. Moreover, Dodge discovered that cultures of the fungus could be spermatized with these microconidia.

The same phenomenon found in the spermagonium of *Gymnosporangium clavipes* will doubtlessly also be found, upon closer observation, to be common for the rusts in general. Moreover, if a similar investigation be carried out on the spermagonia, or pycnidia, of the Ascomycetes, the discovery of a similar method there would furnish us with an even better criterion for determining phylogenetic relationships in methods of spermatial formation in the rusts and Ascomycetes.

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BOXWOOD BLIGHTS AND HYPONECTRIA BUXI

B. O. Dodge

(WITH 2 FIGURES)

Those who are familiar with diseases of boxwood will probably agree that the most damage is due to the leaf blight or die-back disease caused by the fungus usually referred to as *Volutella Buxi*. The perfect or ascocarpic stage of this fungus is said by Pape and others of Germany, and by several American authors, to be *Nectria Rousseliana*. Leaves turn straw-yellow, or light tan colored, and smaller twigs die-back for some distance. Winter injury also results in a yellowing and dying of the top leaves, so it is not always easy to distinguish one trouble from the other. White [1] has described a canker disease of box due to the same fungus. He says that the first symptoms of canker are delayed new growth in the spring and the later yellowing of leaves which are then often attacked by *Macrophoma Candollei*, as well as by other fungi. The bark of the cankered portion of the stem becomes loosened and peels off readily, showing dead discolored wood. He believes that infection takes place when the fungus descends from infected side branches or where quantities of dead leaves bearing the *Volutella* fungus collect in crotches.

Not infrequently one finds pale-pink or coral colored sporodochia of *Volutella*, or a whitish hyphomycetous growth of *Verticillium* on the dying branches and leaves. This has been assumed to serve to distinguish the blight from winter injury. If no spore pustules are evident it is the custom to place the suspected material in a damp chamber or under a bell jar for a few days. Under these moist conditions the fungus will grow out if present. During the past we have had occasion to report on dozens of cases of this box blight. Some years ago in collaboration with Marjorie E. Swift [2] we made rather extensive

[1] N. J. Agric. Exp. Sta. Circ. 226. 1931.

[2] Dodge, B. O. and Marjorie E. Swift. Notes on boxwood troubles. Jour. N. Y. Bot. Garden **31**: 191–198. 1930.

culture studies of the fungi which develop on the dead and dying leaves and twigs. We stated that cultures derived from the *Verticillium* spores develop not only *Verticillium* but also sporodochia of *Volutella Buxi*. Cultures taken from the *Volutella* spores in nature develop both types of spore-producing structures, so that it appeared that *Verticillium Buxi* and *Volutella Buxi* are simply different types of fructification of the same fungus. The writer now, however, believes that there are some grounds for questioning this statement. We have never seen the perfect or ascocarpic stage of *Nectriella Rousseliana* on the blighted leaves in nature, but have always assumed that if one looked in the right place at the right time they must be found.

Late in 1943 Mr. Aymar Embury II of East Hampton, Long Island, brought in some branches of boxwood which showed a number of dead and dying leaves and some shrivelling of the bark. Many of the leaves were marked on the under side by a reddish rust-brown flecking (FIG. 1). Such leaves always had on the lower side many small sunken spots or pits (FIG. 2). On a former occasion, a similar pitting of one leaf of a specimen brought to the laboratory was noticed, but in that case the pitting was associated with small blackish flecks so that superficially the leaf looked as though it had been infected by some spot disease fungus. The material brought by Mr. Embury, however, proved that the pittings represent collapsed subepidermal perithecia. The asci were of the sort commonly developed by species of *Hyponectria*, a genus of Nectriaceae. The ascospores which were being matured were hyaline, oblong and one-celled. Some of the leaves showed a white *Verticillium* overgrowth on the under side and also sporodochia of a *Volutella*. When leaves were soaked for a few hours in water or were placed in a damp chamber over night, one could see by transmitted light that the pits had been filled out with the swollen contents of ascocarps. Some of the perithecia had definite ostioles. It was difficult to separate the reddish brown perithecial walls from the leaf tissues; the lower epidermis also seemed to be more or less involved. After two or three days in the damp chamber one could find where ascospores had oozed out of certain perithecia and collected in amber colored droplets which hardened when

the leaves were dried. A little later more of the leaves became covered with the white hyphomycetous growth similar to that of *Verticillium Buxi*. Rather light pink to dark coral colored sporodochia with setae, resembling very much those of *Volutella Buxi*, also developed. Whether the three forms of fructifications were stages of the same fungus is, of course, problematical. Mrs. Embury later volunteered additional information on this point. She tells us that she had noticed several times during the past summer numerous pinkish pads of fungus growth on the dying leaves and branches, also a whitish powdery growth which often covered the leaves. She thinks that this type of fungus growth more correctly pictures one of the real symptoms of the disease. This would seem to confirm the opinion that their boxwood leaf blight and die-back must be due largely to the fungus *Volutella Buxi* (*Verticillium Buxi* ?).

The blight in this planting is now confined to the variety which they refer to as English box. There is still some uncertainty as to the variety. They are using it as an "edging" plant which is allowed to grow a foot or so high. The leaves are very numerous and so form a compact growth of foliage which might well provide just the ideal conditions for the spread of a leaf blight organism. They report that many of the plants originally set out died. A later examination of the planting disclosed many dead or dying stems, all with blighted leaves. Ascocarps in all stages of maturity were present. Leaves still green also bore ascocarps in the very earliest stages of development. In some cases the color was that characteristic of the Hypocreales. In others, especially where the leaves were still green, the perithecial walls by transmitted light were very dark, even greenish black, so that if Albertini and Schweinitz had such a specimen under examination they would have had good reason for naming their species *Sphaeria atrovirens* var. *Buxi*. Usually, however, the walls are a rusty reddish color. The bush varieties or types in this planting showed no *Hyponectria* blight, but the owners report that they are like a number of others that apparently succumbed to the same disease. An extensive planting of an "edging box" at the Memorial Monument, Bronx, New York City, is free from all diseases. It seems to be a different variety.

The large box plants in that collection have been provided with excellent winter protection. A more extensive study of the whole question of varietal susceptibility, effects of winter injury, wind and sun injury, as well as lack of adequate and correct use of fertilizers will be necessary before a correct picture of these box troubles can be secured.

The question arises whether or not we have two leaf blights or die-backs of boxwood, one caused by an ascomycete which is readily identified as *Hyponectria Buxi* (DC.) Sacc., and the other caused by *Nectriella Rousseliana* (Mont.) Sacc., both having similar conidial stages. Examination of the specimens in the herbarium of The New York Botanical Garden proves that both species of ascomycetes are frequently associated with boxwood leaf blight and that the perfect stages of the causal organisms are entirely different. The only specimen of *Hyponectria Buxi* from America in our herbarium is that originally collected by F. A. Mulford at Hempstead (L. I.), New York, Nov. 27, 1907. The packet is labeled simply *Sphaeria Buxi*. It is accompanied by a note as follows: "Parasitic on box; spray when first appears next season with weak Bordeaux Mixture and repeat every 3–4 wks, or as it reappears. Cut off and burn all affected shoots before growth begins again. Better do it now." This is a fine specimen and the disease symptoms are exactly like those shown by the collection from East Hampton, New York. Some of the sunken or collapsed ascocarps which are subepidermal had matured asci with hyaline one-celled spores. This Mulford collection is certainly *Hyponectria Buxi* (DC.) Sacc., although no *Volutella* or *Verticillium* growth can be seen on the leaves.

Among the other specimens of *Hyponectria* is No. 1280, Desmazières, Plantes Crypt. France. The specimen is labeled *Sphaeria Buxi* nob. Desmazières endeavors, in a lengthy note accompanying the specimen, to prove that his own specimen is not the *Sphaeria Buxi* of De Candolle. He says that whatever fungus De Candolle had it is not his (Desmazières'). It must be admitted that De Candolle's description was rather sketchy. Weese [3] agrees with Desmazières. Saccardo, however, who made a special study of this question, has accepted the De Candolle

[3] Mitt. Bot. Inst. Tech. Hochs. Wien **10**: 87–90. 1933.

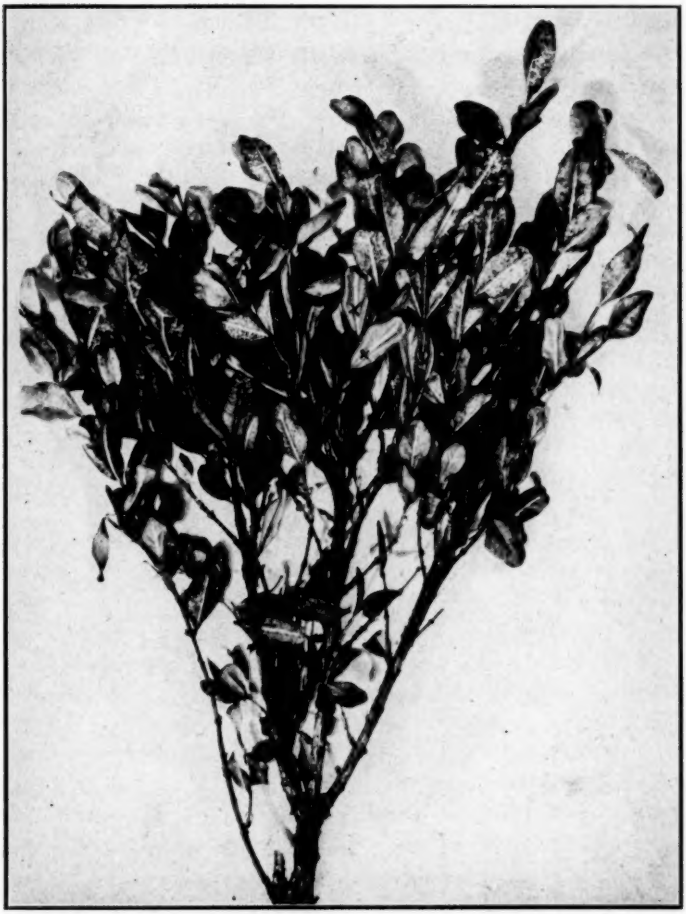

FIG. 1. Leaf blight of boxwood caused by *Hyponectria Buxi* (DC.) Sacc. The topmost leaves were evidently the first to become infected. Several leaves lower down and at the left were still green although most of them bore evidence of the early stages in the development of ascocarps. Two leaves marked "x" at the center are examples of a few green leaves which showed no evidence of infection. Evidently the disease is a leaf blight rather than a leaf spot disease. Slightly reduced in size.

interpretation as the basis for the specific name *Buxi*, and he has, Fungi Ital. No. 200, illustrated this fungus under the name *Hyponectria Buxi* (DC.) Sacc. *Sphaeria atrovirens* var. *Buxi* of Albertini and Schweinitz may or may not actually be the same. Rabenhorst-Winter Fungi europaei, No. 2864, labeled *Hyponectria Buxi* (DC.) Sacc., represents another collection.

A leaf disease of box has been reported in the United States under the names *Laestadia Buxi* (Desm.) Sacc. and *Guignardia Buxi* (Fuckel) Feltz. We have seen no specimens representing these two collections. No. 84, Krieger, Schäd. Pilze, *Laestadia Buxi* (Fuckel) Sacc. has many subepidermal ascocarps dotting the under sides of leaves, some of which are still green. Some leaves bear *Verticillium*. No. 2938, Sydow, Mycotheca marchica *Laestadia Buxi* (Fuckel), shows in addition to ascocarps, a *Verticillium* growth on some leaves. Both collections are *Hyponectria Buxi* (DC.) Sacc., as is No. 178 Briosa e Cavara, Funghi Par., *Laestadia Buxi* (Desm.) Sacc., which illustrates the injury as that of a spot disease.

To return now to leaf blight and die-back of the type heretofore attributed to *Volutella Buxi*, the perfect or ascocarpic stage of which has usually been said to be *Nectria Rousseliana*. The genus *Nectria*, as now understood, includes those species which have two-celled ascospores, while corresponding types with one-celled spores are placed in the genus *Nectriella* Sacc. (*Pseudonectria* Seaver). We find in our herbarium a number of collections of diseased box leaves which carry the label "*Nectriella Rousseliana* (Mont.) Sacc." The two collections labeled *Nectria Rousseliana* are included in the *Nectriella* cover. Krieger, Fungi Sax. No. 427; Roumeguère, Fungi Sel. Exs. No. 6252; Rehm, Ascom. No. 934, are examples of *Nectriella Rousseliana* (Mont.) Sacc. These all show numbers of amber-colored superficial perithecia which are easily dislodged. Some of them have a well marked ostiole and some appear to bear a few hyaline hairs. While many of the perithecia are cracked open and empty, others contain mature asci with eight one-celled spores. Frequently the same leaves bear remains of sporodochia of a *Volutella*, but it is difficult to find attached spores. A *Verticillium* ? hyphomycetous growth is often present.

Saccardo, Fungi Ital. plates 199 and 200, illustrates side by side *Nectriella Rousseliana* (Mtgn.) Sacc. and *Hyponectria Buxi* (DC.) Sacc. His figures bring out clearly the essential differences. The first, No. 199, figures a typical superficial ascocarp of the *Nectria* type. The second, No. 200, shows diagrammatically subepidermal ascocarps of the *Hyponectria* type.

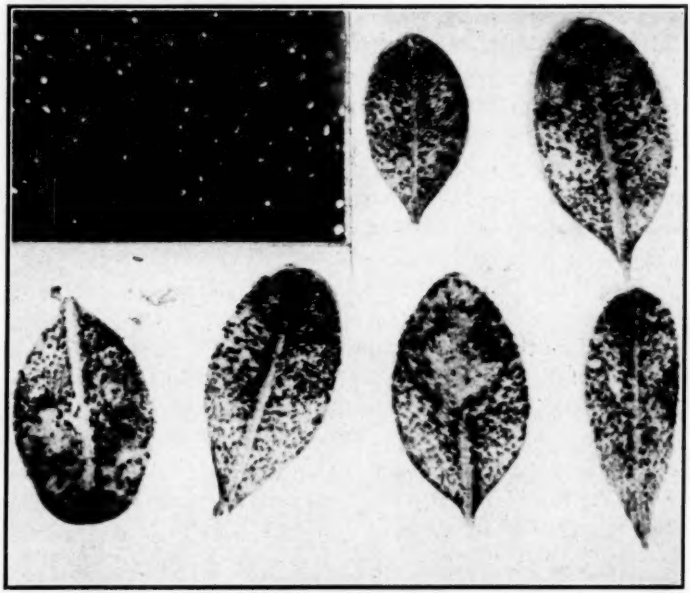

FIG. 2. *Hyponectria Buxi* (DC.) Sacc. Upper left. Under side of part of a dry leaf of boxwood photographed by transmitted light to show the pits which represent the translucent shrunken and collapsed ascocarp contents. This is the condition in which the ascocarps pass the winter. Asci are usually present. Some already contain ascospores but in most ascocarps the asci will probably pass the winter in the uninucleate resting stage, × 12. The other leaves show on the lower side the raised or pimply spotting ascocarps after the leaves have been kept in a moist chamber for a day or two, × 2½.

In our herbarium there are several specimens of *Verticillium Buxi* (Lk.) Sacc. Several of them were collected by F. W. Anderson at Washington, D. C. One was collected by L. E. Miles at Corinth, Massachusetts. There is also one collection of *Volutella Buxi* Berk. from Philadelphia, Pa. These specimens

were examined but no ascocarps of either *Nectriella* or *Hyponectria* were found.

The Embury specimens are also interesting because of the ease with which various stages in the development of pycnidia of *Macrophoma Candollei* can be followed in damp chamber cultures. Most pycnidia mature only the very large *Macrophoma* type of conidia, while others, even on the same leaf, are filled with great quantities of microconidia. These are borne on very definite, rather long conidiophores similar in arrangement to those which bear macroconidia. More rarely, still other pycnidia develop quantities of both the *Macrophoma* and the microconidial types of conidia. This phenomenon is not unknown in the fungi. Pycnidia of *Sphaeropsis malorum* occasionally develop two kinds of conidia, the one large, the other small. Spermogonia, micropycnidia, of *Phoma carpogena* may develop a few large conidia along with myriads of spermatia or microspores.

It is clear that all this confusion in regard to boxwood leaf blight and die-back can not be clarified until cultural studies of both the *Nectriella* and *Hyponectria* are made, beginning in each case with single ascospores. Such studies followed by infection experiments will enable one to determine the status of *Volutella Buxi* and *Verticillium Buxi* and will no doubt give us some other highly interesting information.

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